FORESTRY

THE JOURNAL OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

Edited by H. M. STEVEN

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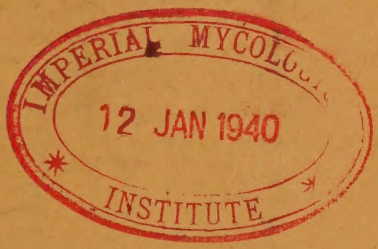

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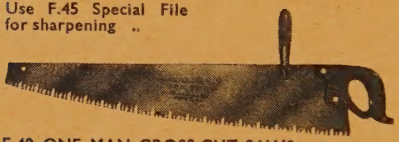

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FELLOWS, being holders of a degree or diploma in forestry, and subjects of the British Crown, but not necessarily resident in Great Britain; and

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THE SOCIETY AND ITS JOURNAL

THE IMPORTANCE OF FORESTRY is being realized more and more in Great Britain. The number of foresters is increasing steadily, and a forestry profession is gradually being built up. It is intended that this Society should be representative of the profession. Those who are not engaged in the practice of forestry or the allied sciences are cordially invited to join the Society as Ordinary Members.

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THE SOCIETY'S JOURNAL, called *Forestry*, is published twice a year, in June and December. It provides a means for the publication of the results of practice and research both in the growing of timber and in its utilization, including such basic sciences as forest physiology and ecology, forest soils, wood structure, and timber physics, and allied sciences such as forest entomology and forest mycology.

CONTRIBUTIONS may be accepted from members and others resident either in Great Britain or abroad. They should be sent to the editor, Professor H. M. Steven, 75 Fountainhall Road, Aberdeen. No article should be submitted which is being offered to any other journal for prior or simultaneous publication. Articles should be typewritten, and on one side of the paper only, and must be in a final form suitable for publication. References to literature should be collected at the end of the paper, and arranged alphabetically according to author's name, and numbered. In the text each reference should be indicated by its number enclosed in brackets. Each article should conclude with a summary. It should give the methods, extent of material, observations, and results, but should be brief and not exceed 3 per cent. of the original. It is understood that the author waives any copyright or translation rights in such summaries and that their reproduction in other publications will be permitted, subject to the source being duly acknowledged. Twenty reprints of the article will be sent free to each contributor and a reasonable number may be purchased by the contributor if ordered when the proofs are returned. The Society as a body takes no responsibility for the views expressed by contributors.

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SOCIETY'S MEDAL. The Council has resolved that the Society award a Medal from time to time to any individuals who may have rendered eminent services.

FORESTRY

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FORESTRY, FORESTERS, AND FOREST POLICY IN GREAT BRITAIN[1]

BY W. L. TAYLOR

TO those of us who have forestry, and particularly forestry in Great Britain, so much at heart the forest history of our country presents rather a sorry picture of waste and indifference. The fact is that our social, political, and economic systems for as long as a thousand years have combined to oust the industry of forestry from its natural position in our rural economy; in plain truth, as a nation we have not been foresters at all.

To the end of the nineteenth century and after, systematic forestry was an unknown quantity in Great Britain, and even to-day, when the urgent need of stocks of forest-grown timber within the country has become apparent to any one who will think, the older woodlands are apt to be valued for amenity or for the pheasants they will hold rather than for the timber they could produce. The rake's progress of our woodland management is easy enough to trace. It is true that in times of stress the public conscience has been aroused, and at several periods in our history Parliament has endeavoured to restrict wasteful fellings; fashions for planting, always short-lived, have also arisen at periods generally following one of the major wars in which the nation has been engaged, and, as we know, it required the greatest war of all time to induce us to adopt a forest policy as part of our national organization. It is only in the present century that a planned national effort has been made, and what has been done is only a beginning. The benefits of systematic forestry to the more remote rural districts will not, I fear, be brought home to the people of our country until the new forests now being raised up come into rotation, and in their sustained yield give practical evidence of their value to rural industry and as a national standby.

There is abundant evidence that in the days of pre-history this island was extensively clothed with forest. In some parts, the primeval forest was thickly and evenly stocked and in others the natural woodland was open or even mere scrub. It may be assumed that in earliest times man had less influence on the forest than the forest itself had in restricting his own activities. To the ancient Briton in his dawning culture, dense forest must have been a thing to dread. Nevertheless, it was the man who first fashioned and hefted a tree-bough who held in his hand the prototype of all subsequently developed instruments of husbandry and all smiting and thrusting weapons. The first man who bent a pliant sapling as a bow gave birth to weapons of precision, and at almost every turn in the early struggle for supremacy over nature it

[1] Delivered as the Presidential Address at the Annual Meeting at Scarborough on 12 July 1939.

was to the products of the forest to which he must have turned for material on which to exercise his ingenuity. It may be truly said that there were many wooden stepping-stones to early civilization. It is evident that in course of long ages fear of the forest and what it held became less and less, until with the spread of population, the accumulation of flocks and herds, and the cultivation of crops, battle with the natural woodland was joined in earnest. The rape of the forest grew in intensity until to-day we are left with but inconsiderable vestiges of the ancient forests of Britain.

I believe that the earliest record we possess of an effort of forest conservation is contained in the Laws of Ine, King of Wessex, who early in the tenth century enacted, quaintly, that trees destroyed by fire were to be paid for at the price of sixty shillings each because 'fire is a thief'. He charged only thirty shillings for those felled by the axe because 'the axe is an informer and not a thief'. By this time, axe and fire, and probably browsing, had certainly made increasing inroads, and forest destruction must have been continuing steadily. So we come to 1066, easily the best known date in English history. It is also a date of note in forest history because it brought with it *lex forestae* of the Norman régime. I think that it is possible to trace the decline of British forestry (in the sense that we use the term) to the coming of the Normans. We know what they meant by a forest and that they valued venison more highly than vert. We know also that the common people of England were not encouraged in those regions legally declared to be forest. Breaches of forest law met with savage penalties, and may we not assume that in the minds of the people the 'forest' once more became a forbidden and fearful land and that this impression left its permanent mark? The woodland warning 'Beware of man-traps and spring guns' will still be within the memory of some of us. In spite of itself, however, the Norman method of forest closure had some good influence for posterity because, so far as browsing permitted, natural regeneration took place over many of the 'forests'. The sequence of events during the following millennium is to-day too plainly written upon the country-side to require further mention.

The major planks—to use a term in keeping with our subject—in the forestry programme of to-day are supply and the rehabilitation of our depleted rural areas. Bearing in mind the ephemeral nature of previous bursts of forestry activity in Great Britain, which usually followed the periodic scares concerning oak for the Navy, or were induced by the action of persons of influence as by the teaching of John Evelyn and the example of the fourth Duke of Atholl and his predecessors, we must hope that the present organized effort will live to demonstrate the full and true value of systematic forestry to the nation. There is much missionary work to be done, however, and in this the members of our Society can take a leading part, using both the spoken and the written word. Forestry in the abstract is attractive to many people, but the full tale of its merits is understood by only a few, and the economic benefits arising from its practice by even fewer. If I may tamper with a line from a well-known poem, may it not be said: 'What know they of forests who only

England's know?' Our continental friends are well aware of the value of sound forestry practice, while we, as a nation, only know that we get all the wood we want and do not, in general, give much thought to where we get it from or to the economics of the matter.

In this country, systematic forestry is a new thing and as such is often suspect. The innovation brought about by the Forestry Act, 1919, is as yet not very widely understood, and why should it be otherwise, for ours is so much a land of woods, coverts, and hedgerow timber that the need to practise forestry is obscured by the very numbers of the trees. As a new national industry our work still entails the hoeing of a lengthy row before it will receive full recognition. The single fact that afforestation involves change in the utilization of land is more than enough to cause opposition, apart from many minor considerations.

It is justifiable to inquire what forestry actually is. Is it a science, an art, or a business? Surely forestry, in each of its main branches, silviculture, management, and utilization, is first and last an industry. In the raising and tending of forests each skilled task is itself an art, while in the successful practice of forestry empiricism is making way for the surer bases of scientific discovery in the many fields into which the foresters' problems extend. Science and art are, therefore, ancillary to the industry of forestry, which can be defined as the raising, tending, protecting, and utilizing of timber crops with the object of maintaining the maximum sustained yield from any given area of forest.

In countries possessing forests or wishing to possess them, forestry activities must be regulated by national forest policy. Forest policy can be framed only after the consideration of many factors, not all of which lie within the province of the forester. Broadly speaking, forest policy, like any other, should be drawn up to serve the full range of a nation's interests. Great Britain's excursion into national forest policy is yet very young, and, it may again be said, so narrowly understood, that it may be of advantage to examine the benefits likely to accrue in this country. As we know, the goal aimed at in 1919 was the afforestation of 1,770,000 acres of bare land within a period of 80 years and the reconditioning of as much as possible of the 3 million acres of woodland in private ownership. Taking the short view the immediate task has been, and is, to ensure as speedily as possible an adequate supply of pit timber in case of need, the replacement of the 450,000 acres or so of woods felled between 1914 and 1918, and incidentally to provide permanent employment and facilities for land settlement. In the larger aspect, the intention is to build up the nation's forest resources to the extent envisaged by the full 80-year programme. The real point is that a nation's forest policy, if it is to succeed, can never be a short-term consideration, and no policy can hope to endure over a long term of years if it is not manifestly of real value. What, therefore, has a forest policy to offer to the people of Britain?

In the first place our present reserves of readily exploitable standing timber are admittedly not extensive. Furthermore, in consequence of lack of method, a proper age-class distribution scarcely exists, and lastly our area of woodland,

that is our existing timber-producing area, is quite inadequate from every important point of view. I have spoken of some of the reasons for this state of affairs, but have only briefly mentioned yet another. Hitherto we have been able to buy all the wood we have needed abroad, and it is just that facility with which timber has been imported into this country that has been so potent an inducement to forest neglect. As a nation we have been importers of timber at least from the eleventh century. The question is one of supply, and although we cannot hope to become self-supporting as a result of present policy we can build up and maintain stocks of merchantable timber in our forests and woods on the principle of sustained yield that will enable us to meet any emergency, and in time to effect a substantial reduction in the large bill now paid every year to exporting countries.

Secondly, the annual out-turn of a known volume of timber will enable the sawmilling and wood-working industries to expand and organize, because the primary essential in the development of manufacture is a sure and regular supply of raw material.

Then there is the lasting good a new industry can do in the direction of employment. Every newly created job of work requires its man to do it, and although at first the amount of employment may not be spectacular, the numbers permanently engaged grow as timber production advances. The labour required to tend and protect an established forest, and to fell, extract, and utilize the timber very greatly exceeds the five men per thousand acres which, on the average, suffices in the early stages of afforestation.

Again, and this is certainly one of the not inconsiderable benefits, forestry offers a safe and certain means of permanent land settlement in and about the forest. Past experience has gone far to indicate that rural repopulation in Britain, which is one of the urgent and most difficult problems of modern times, can only be successful if accompanied by a guarantee of work for wages such as forestry can offer.

Fifthly, the creation of forests is also the creation of wealth, and there is so much land throughout this island that will, within the range of practical economics, produce more wealth per acre per annum under a forest crop than any other, provided sound systematic forestry is practised.

Lastly, there is the psychological value of forests as a national possession, a value that many people in this country are inclined to belittle and even deny. This attitude arises mainly from lack of foresight and inability to look beyond the young growing plantations of to-day. In regard to amenity, there is no species of forest tree, broadleaved or conifer, with which imposing landscape effects can be obtained in the early stages of growth in plantation, but, as the nation's forest resources have so dwindled, forests, if we are to have them at all, must be built up again. To effect this purpose there has to be a beginning. It is fair to ask the acutely aesthetic minded not to take the short view, but to look ahead to the mature forests of future years, to forest industry and the busy and increasing community of forest workers who have already begun to find home and livelihood within afforested areas, and also to the

welfare of the generality of the people of Britain who will find healthy recreation in and about the forests and in the National Forest Parks on which a start has been made, as the peoples of other nations are finding it in theirs. In this regard it is good to reflect that the threat of the man-trap and spring-gun lies behind us. Forest-minded nations are everywhere proud of their forests, and this is true of their urban peoples as well as the country-dwellers.

There can be no national forest industry without a policy, and national forest policy to be of service must be well-conceived, well-balanced, and steadfastly persevered with.

We may briefly consider the land as the basis of primary production in general, including timber production. Science and experience enable us to take liberties with mother earth, liberties to be regarded as privileges rather than the liberties they are because, if there is over-stepping, the trespass will never fail to bring its penalty. Sympathy and understanding, that is 'land sense', is an essential part of the successful forester's make-up, and is the secret of proper land utilization. It is a narrowly conceived error to imagine it possible to go gaily on afforesting and to regard problems of land utilization and management as incidental. They are not merely incidental considerations, but are fundamental, and they beset forestry in greater or less degree wherever it is practised. A working knowledge of problems of land management is required of foresters of to-day, and even in the vast areas of forest in America it is to be noted that the administrative demands upon the forest services in this regard are continually growing. Those who have had experience in the Indian or Colonial Forest Service will also appreciate this point.

Finally, I would say a word about forestry as a profession, because our Society was founded for the professional foresters of Great Britain. I have defined forestry as an industry, but for those in control of forest policy and administration it is also a profession, as in the case of those in the higher control of engineering, mining, and other projects in the great industries concerned. A professional man may be said to be one who has equipped himself with specialized knowledge and is able to offer it for the service of others. It is idle to ask what kind of man will make a good forester, but he must at least be a man of character and intelligence and be possessed of good health. In point of fact he must be more than this, for forestry does not offer a comfortable round hole to the square peg. Important characteristics are understanding, resourcefulness, assiduity, business-like habits, ability to express oneself clearly, leadership, optimism, sense of humour, courtesy and tact, and last but not least a strong sense of public service and the ability *and the will* to co-operate. Interest in true sport, outdoor life, and things that grow are helpful attributes, or, to quote from a work on forestry recently published in the United States, 'keen interest in the forest as a community of living organisms that will yield to man's manipulation, characterizes every true forester, even though he spends more time with maps, adding machines and people than he does with trees'.[1] Without the right types of men forestry cannot hope to take and

[1] *An Introduction to American Forestry*, by Professor Shirley W. Allen, University of Michigan.

maintain its proper place in the economics of our country and as a branch of British husbandry.

The rewards of a professional forestry career may not appear startling in comparison with some of those yielded by the older professions or the business world, but they probably compare reasonably well with the average of either. As a profession, forestry, in the modern sense, is in its youth, and future prospects are likely to be in proportion to the value of the public service rendered by those engaged in its practice, as prospects are in any other profession. It may seem trite to remark that there are other considerations, but without being self-righteous we may nevertheless say that there are. There is the fact of association with a great creative work, the satisfaction arising from the practice of just those qualities the work demands, the joys of dipping into the secrets of nature and making things grow, the benefits of a life that is largely out-of-doors, and the means of developing a greater breadth of interest than is readily attainable in the everyday routine of so many other callings. Each different occupation imposes its own particular discipline on those who follow it, but on none need the shackles sit more lightly than upon those whose life work lies in the creation and maintenance of forests.

NORMANDY REVISITED

BY SIR ALEXANDER RODGER

THE writer was fortunate enough to be asked to visit Normandy with the late Professor Troup and his class from Oxford in July 1938. This second visit was separated by 42 years from his first visit with Mr. W. R. Fisher's class in 1896. Mr. Fisher was then assistant to Sir William Schlich at the School of Forestry at Coopers Hill, and he was accompanied on this tour by Mr. H. C. Hill, later Inspector-General of Forests to the Government of India, and Mr. Bayliss, who was Deputy Surveyor in the Forest of Dean under the old Department of Woods and Forests. It would have been interesting if the writer had been able to produce his diary of that early date, but unfortunately wanderings and white ants had caused it to disappear.

LYONS LA FORÊT.

Our first halt was made at Lyons la Forêt. After a period of disagreement with the proprietors of this forest hotel, due to an indiscretion of one of the Coopers Hill students who decorated the image of the Unicorn, the Hotel de la Licorne has been for some time the annual rendezvous of the Oxford students, and it seems still to retain its old-world character, primitive in some ways but comfortable on the whole.

This fine beech forest, extending to about 25,000 acres, came under systematic management in 1669, and the records actually go back about 400 years. Beech forms rather more than half the total crop, hornbeam one-quarter, oak about 20 per cent., and ash, &c., some 3 per cent. The writer was impressed with the large extent of pure, or almost pure, beech, and cannot help thinking that other and more valuable species should be introduced over considerable areas on suitable soils.

The forest was worked under the old *tire et aire* system until 1856. I am permitted to quote from Professor Troup's and Mr. Lloyd's notes which are here, and later on in the article, given in inverted commas, 'Under this system, adopted in terms of a Royal Statute of 1669, equal areas of forest were cut over in clear fellings, a varying number of trees, usually not more than about eight per acre, being reserved as seed-bearers. The young crops which sprang up were left to themselves for the whole rotation, without being tended.' The Uniform System and fixed periodic blocks has been used since 1856. The object of the seeding fellings, as now carried out, is to admit light and warmth to the ground, and the method adopted is to raise the canopy, that is, get rid early of the low branching stems. Hornbeam appears in quantity if openings are made too rapidly, as it needs more light than beech. All advance growth is cut out because uniform crops are required and wolf-trees are much dis-

liked. This attitude seems rather too conservative. Secondary fellings may be carried out to any number, every 5 or 6 years, as required. Skilful silviculture and detailed and constant inspection are required to make this system a success. The whole process takes about 30 years over the whole periodic block. There are fifteen felling series, each containing complete gradation of ages, and each worked independently of the others. The felling series are fixed on the following requirements:

1. Local markets must be supplied all the time from forests within easy reach.
2. The staff must be given constant employment.
3. Existing roads should be used every year.
4. Labour must be economically distributed.

ROUVRAY.

The next forest visited was Rouvray, a few miles south of Rouen, in area about 8,000 acres, of which about three-quarters consists of Scots pine, a tree that was introduced more than a hundred years ago.

'The serious deterioration of the Scots pine forests during the past 10 years indicates an urgent need for protective measures. The attempt to grow a dense stand of pure pine on poor soil without an admixture of broad-leaved trees has rendered the forest particularly susceptible to disease. The dying back of the Scots pine has been attributed partly to the *maladie du rond* and to sulphur fumes from the Seine Valley. The problem was investigated by Mr. W. R. Day (see Oxford University Forestry Society's *Journal* for 1935), and one of the conclusions reached was that under-thinning, in the attempt to get a large volume of pit-props, was a predisposing cause. Other factors were: (1) poor soil conditions, in some areas accentuated by alternate drought and flooding, (2) defoliation by insects and infestation by bark-beetles, (3) fungus attack, *Armillaria mellea* and *Fomes annosus*, (4) sulphur fumes in factory smoke, (5) fire damage. Protective measures undertaken are: (1) the introduction of broad-leaved species, beech, hornbeam, *Robinia Pseudo-acacia*, and chestnut, (2) heavier and more frequent thinning, (3) removal of diseased trees and stumps, (4) fire protection.'

Cleaning and thinning appear to have been neglected for the sake of economy, and very obvious damage has been done by wind, fire, fungi, and insects. It must be admitted that the forest as a whole presents a depressing picture.

Regeneration of pine is attempted as follows:

1. Uniform fellings under the Shelter Wood Compartment system, when the isolated seed-bearers are often blown down.
2. Strip felling, leaving seed-bearers in narrow belts. Failures are not uncommon owing to rabbits, absence of sufficient seed, and strong growth of weeds.
3. Sowing and planting. Sowing in cleared patches is preferred to planting,

and care is taken to remove surplus plants from successful patches to blanks.

The soil in this forest is acid and highly podsolized. Heather is common, with *Molinia* in some parts and bracken elsewhere.

BELLÊME AND RENO VALDIEU.

The splendid oak forests of Bellême and Reno Valdieu were next visited. Similar soils in these two areas have produced fine timber in both. Clay with flints overlying chalk and patches of pure sand occur in places. Sessile oak is grown on a rotation of 200 years. Here again advance growth is cut out because it is believed that it cannot produce a good crop after suppression for some years. 'Although the regeneration period is 25 years, the actual time between the seeding and the final felling may be as short as eight years.'

The working plan was drawn up in 1856 and has been revised every 25 years. The oak timber is valuable and sometimes fetches 1,200 francs per cubic metre for veneers, a good deal going to Germany.

Recently a new system of thinning has been introduced, aimed at producing short thick stems instead of long thin boles, and it is expected that the volume of timber produced per hectare by this method will be increased. A thick understory of beech must be maintained to protect the soil and prevent epicormic branches appearing on the oak.

The above applies to Bellême, and Reno Valdieu is similar, but it has a shorter rotation, 180 instead of 200 years. Both forests contain magnificent oak, some of the trees being 400 years old, but they are now to be felled.

In *Sylva*, the Journal of the Edinburgh University Forestry Society, No. 19, Professor Stebbing writes on 'The Passing of La Plantonnée, Forêt de Tronçais', one of the finest old oak stands in France. He records how some of the magnificent oaks about 250 years old were felled for the French Navy in 1918 but were never extracted. After the war the French Forest Officers decided that as what was really a seeding felling had been partially carried out the process should be continued. In 1922 a perfect picture of the beginning of natural regeneration was seen. In 1937 the giant oaks had nearly all gone and a photograph is published of one of the finest as it lay on the ground, a log 9½ feet in girth at 4 feet 3 inches, 100 feet long, and 4 feet in girth at the top.

ECOUVES.

The forest of Ecouves has a vegetation rather like that of Tintern with bilberry, bracken, *Deschampsia*, and a little *Molinia*, and much moss was seen on the ground and on the trees. The extent of the forest is about 32,000 acres, and it lies near Alençon and is for the most part on a poor acid soil. The principal species are oak 45 per cent., Scots pine 25 per cent., beech 15 per cent., and there are also birch, aspen, ash, spruce, Silver fir, and Maritime pine.

'Ecouves is an ancient Royal forest and systematic management began in

1667. Until 1867 it was treated partly as coppice-with-standards and partly under the *tire et aire* system. In 1867 it was decided to convert the whole forest, except the northern and western sections, into high forest; the best areas to be regenerated naturally by the Uniform System, and the poorer parts to be replaced by Scots pine or Silver fir, according to the altitude and exposure. The rotation of the Scots pine and Silver fir to be 120 years. The northern and western sections, which are on the poorest soils, are at present retained as coppice-with-standards on a coppice rotation of 30 years, with thinnings every 10 years. The high forest of beech and oak has a rotation of 180 years, divided into six periods of 30 years, the periods being as follows: I: 1863–92, II: 1893–1922, III: 1923–52, and so on. The same periods are adopted for the conversion of coppice-with-standards into high forest.

'The revision of the working plan, in 1880, prescribed that where growth was good the conversion should be made by retaining a large number of coppice shoots, together with the younger standards, and allowing them to grow up into high forest. This method was further developed by M. Aubert, formerly officer-in-charge at Alençon, and it became recognized as the Aubert system of conversion.'

Three criticisms may be made of the work in this forest:

1. Patch sowings of Silver fir are not properly tended. Superfluous plants should be transplanted.
2. Contractors are leniently treated and let off for bad work with a small fine.
3. Conifers are badly pruned and ugly snags were seen near roads.

A very serious fire burnt a large area of forest in 1938, but only a small part belonged to Government. It is difficult to induce private owners to pay for their share of making fire-traces and maintaining watchers.

THE LANDES.

The tour ended at Mimizan Plage, where a short holiday was combined with an extensive inspection of the well-known Landes forests. These forests of Maritime pine cover an area of about 800,000 acres and occupy a stretch of country which was formerly a waste of shifting sands. Afforestation began in 1787 but was not carried out on a large scale until 1817, and no success was attained until the littoral dune was fixed with Marram grass. This grass is planted in December and January, to take advantage of the moisture in the ground, behind a palisade and wattle fence, which form a dune parallel to the seashore.

The pine seeds freely every year and natural regeneration is easy, but it is found that root competition from old forest prevents the seedlings from flourishing. Clear fellings take place over large coupes, and ditches are dug around them to prevent the roots of the adjoining trees from occupying the ground. A protective belt is maintained along the seashore and only dead and dying trees are felled in this. The rotation is 72 years and thinnings are carried

out every 4 years. The stand of trees is, at 20 years of age about 220 per acre, at 45 years about 80 per acre.

Resin tapping is carried out everywhere under elaborate rules. The resin commands a good price and the timber also sells well—pulp, pit-props, packing-cases, &c.

'The yield of crude resin varies with: (1) the vigour of the trees; (2) the temperature, hot seasons and localities giving more resin than cool seasons and localities; (3) the year of tapping (see below); (4) the skill of the tapper.'

'Tapping produces "wound response", the amount yielded being greater in the 2nd and 3rd years than in the 1st year. This holds good also for *Pinus longifolia* in the Himalaya.' Turpentine is distilled in distilleries near the forests, the crude resin yielding about 20 per cent. turpentine, 70 per cent. rosin, 10 per cent. waste.

There are few better examples of how barren lands can be made to pay than the Landes of France.

A BEECH ASSOCIATION NEAR THE MEDITERRANEAN

BY T. W. SUMMERS

THE remains of a north temperate vegetation can be found within 15 miles of the Mediterranean. This relic covers about a quarter of a square mile on a slope of the Chaîne St. Baume, near Aix-en-Provence. In this region the surrounding forests consist of open stands of *Pinus halepensis*.

Several circumstances have led to the preservation of this vegetation, of which probably the most important has been the presence of a grotto as an object of veneration. In Roman times this mountain slope must have been treated as a sacred grove and thus escaped clearance. Later, in Christian times, the legend grew that the grotto served as a refuge of Mary Magdalene. The natural causes for the survival of this vegetation have been the altitude, the northern exposure, and the comparatively high rainfall.

Starting at sea-level and going northwards, one passes through several forest associations. These will be described briefly before an account of the relic is given.

The hills here extend right to the sea, and on their rocky and shallow soil there is an open growth of *Pinus halepensis*, together with shrubs of *Quercus coccifera* and juniper. The pines seldom exceed 50 feet in height and 20 inches diameter, and, as the hill slopes are very steep, the extraction of larger timber would be too expensive. At 1,000 feet the pines give place naturally to oaks. At the lower levels *Quercus ilex* is more common and at the higher levels, *Quercus pubescens*. For the last hundred years, however, the pine forests have been extended in favour of the oaks and it is now necessary to preserve the oaks so that the stand is not purely of pine. If the stand becomes pure, there are two disadvantages: the lowering of soil fertility and the increase of fire danger.

At 2,000 feet the *Pinus silvestris* begins to appear; a poor race, with crooked stems and few trees over 25 feet in height. This Mediterranean race has very short needles so as to reduce transpiration, and it is in the southernmost limit for *Pinus silvestris*. Associated with the pine are oaks, *Acer Montpellier*, *Juniperus phoenicea*, and *J. communis*. Of the latter, one tree was observed 12 feet high with a single trunk. Farther north this species always occurs as a prostrate shrub. There was no closed canopy, the trees occurring as in open bush country. This meant that the air temperature in the forest showed no obvious reduction compared with the temperature in the open. On the more exposed places the pines were seldom over a few feet high, resembling the 'Kneeholz' seen in Silesia at 3,300 feet. In heavy frosts the leading shoots of the young *Pinus silvestris* remain unaffected, while those of any *P. halepensis* at the same elevation are killed. In the ground flora of this association are *Rosa canina*, *Thymus* spp., *Cistus de Montpellier*, lavender, *Euphorbia*, *Erica*, and *Viburnum*.

At 2,500 feet before the final ascent to the ridge, there was a small plateau. This contained very little vegetation and the surface was dry and stony, the shrubs which did occur being of a xerophilous type. There were a few houses and a convent on the plateau.

It was from here that the relic vegetation started. The sudden change in the vegetation could at once be noticed. From where the slope recommenced one entered the shade of the trees and there was a decided drop in the temperature: inside cool, while outside the sun beat down and was reflected by the dry, hard surface. The first stand in the relic vegetation was an association of oaks—*Quercus ilex* and *Q. pubescens*—similar to the association 1,600 feet lower down, only here the trees formed a dense stand as though in a plantation. They gave a full closed canopy and the trees were on an average 35 feet in height with a diameter of 12 to 15 inches. There was a greater air humidity here and the humus layer gave a dampness to the soil; other contrasts with conditions only 50 yards away on the exposed plateau. As the slope increased, the oaks were replaced by an association of beech (*Fagus silvatica*), with yew and sycamore. The trees were now bigger, the beech being 70 feet in height with trunks 2 feet and more in diameter. The ground was strewn with rocks, but was sufficiently damp for a profuse growth of mosses and grasses. In the openings and along paths one found the common woodland plants of temperate forests—nettle, herb Robert, buttercup, dandelion, saxifrage, umbellifer, *Oxalis*, and *Cornus*. In some parts there were trees of holly in the understory and the trunks of the hardwoods had ivy climbing up them. At about 1,000 feet below, in contrast to the ivy, some of the trunks of the pines had lichens on them.

A little farther up the slope the beech remained, but its associates of yew and sycamore were changed for lime and elm. Mosses covered much of the ground and the ground flora had, in addition to the flowers mentioned above, flowering nettle, *Daphne*, and *Stellaria*. At the upper limit of this hardwood relic vegetation, at 3,300 feet, the grotto is situated. This vegetation extends from an elevation of 2,750 feet to 3,750 feet. The ridge of the Chaîne St. Baume is at 3,750 feet.

In front of the grotto a platform has been built and there are houses for members of a religious order and for selling religious objects. The grotto itself has been laid out as a chapel, with drains to lead off the continuously dripping water. From the platform one has an extensive view of the surrounding hills. These seem mostly to have pine forests and, on the lower slopes, if not farmed, a mixture of oaks and pine. This temperate vegetation could be seen to extend for about a mile on either side of the grotto, rising through an elevation of about 500 feet. Along its upper limit and the two ends there was an abrupt change to the open forest with scattered and short trees of pine and spruce, typical of high altitudes and dry conditions.

It would be interesting to know if this vegetation had once been more extensive before the tertiary upheavals which gave rise to the Alps and caused the hilly character of Provence. This beech association might have remained

the climax type for the region, if the forest had been left undisturbed. Between two and three thousand years ago the population must have been much denser than now, as one can readily see by the many deserted, terraced slopes. There would then have been a demand for agricultural land. To satisfy this, the forest would be destroyed. Extensive clearings over large areas would affect the climate by reducing humidity and rainfall, and thus lead to a retrogression of vegetation. Only under the most favourable circumstances, such as a northern slope and a high elevation, could the former climatic type remain. Over the rest it was displaced by a lower type of vegetation, more xerophytic in character, in which conifers replaced hardwoods. The present common vegetation is that of the Mediterranean regions of North Africa, of Palestine, Syria, and the shores of the Black Sea.

This relic requires protection. Once it has disappeared there would be no possibility of reintroducing it. The required humidity and rainfall would have been lost. It might be possible to extend the forest, especially in that portion farthest from the prevailing wind. Visitors have to be watched and are prohibited from plucking flowers or removing branches and timber. The forest service, under whom this relic vegetation is managed, do all they can to maintain and increase the existing area of this interesting forest.

HEDGES IN FOREST NURSERIES

BY CHARLES LAMONT

(Royal Botanic Garden, Edinburgh)

Introduction. Hedges are living fences and have many uses. In nurseries, however, their principal use is as wind-breaks. They should be kept to formal outline, and clipping, if time permits, should be done twice a year. This will produce a fine compact hedge which should never be allowed to get too wide, because a narrow well-kept hedge will give as much protection as a wide cumbersome one.

In Britain we do not use nearly so many different genera and species as is done, say, in America. In this country we have shown little enterprise in trying species for hedges. Practically any shrub can be tried; some will fail, but only in this way can new useful hedging species for different conditions be obtained. One thing that should be avoided when selecting plants for hedges in a nursery is species with greedy roots, although one could get over this difficulty by putting a path or trench alongside the hedge. The common yew makes a fine hedge and if well kept gives good protection. Its roots, however, will soon penetrate a border alongside and form a network of small roots, taking up all the nourishment for a few yards from its base. Elm and laurel also come into this category, for both are very greedy rooting species.

Privets. Privet makes a good hedging plant and some of the later introductions from China are specially fine. *Ligustrum ionandrum* is a dense spreading bush with leaves less than an inch long. This shrub thrives best on a sandy loam, where it will grow to about 8 feet or more in height. It is easily propagated from cuttings or seed, but is very slow in growth, although it will ultimately make a fine compact hedge. Closely related to it is *Ligustrum Delavayanum*, another Chinese species. This is a taller and faster-growing plant, and makes a lovely hedge of 6–7 feet. It is a much more open shrub with long graceful branches and black fruits. It is also easily propagated from seed or cuttings.

Brooms. Brooms can be used for hedges, and they will make a good hedge in 3–4 years. The common broom makes quite a useful hedge about 6 feet high, but when 10 or 12 years old it is inclined to die out in patches. Much better results will be got from *Genista virgata*, a broom from Madeira which is quite hardy. It has a bushy habit, and will grow 10 feet high or more. It is usually very floriferous and produces seed freely. Seed sown in a frame or open ground should be transplanted out about a foot apart at the end of one year into the place where the hedge is required, because brooms do not care for moving when older. This Madeira species is a fast grower capable of forming a hedge in 2 or 3 years' time. The silvery green of its young shoots gives

it a very attractive appearance. Owing to its fast growth it is best pruned at least twice a year, and this heavy pruning keeps it in excellent shape and will result in a fine hedge of 6 or more feet high.

Lonicera nitida. This neat box-like evergreen honeysuckle is another species which makes a fine quick-growing hedge. *Lonicera nitida* is very easily propagated from cuttings which will root in an open frame in a few weeks.

Olearia Haastii. This species, an evergreen bushy shrub from New Zealand, is very hardy. To make a good hedge pruning should be done either in early spring or after August, as abundant white flowers, which show up well against the dark green leaves, are usually produced in July or August.

Sea Buckthorn. The Sea buckthorn, *Hippophae rhamnoides*, is a plant which will thrive almost anywhere. It does not seem to mind whether it is near the seashore or farther inland, or whether it is exposed in the worst windy positions; it grows equally well in any place. This is a plant that can be recommended, and although it is deciduous, it makes a very pretty hedge of silvery grey during summer.

Osmanthus aquifolium. This species, a native of Japan with dark green, polished, holly-like foliage, can easily be distinguished from the holly by its opposite leaves. It will grow 10 feet or more high and will make a successful hedge in not too exposed localities. This plant does not mind some shade.

Hollies, Box, and Beech. Nothing is better for hedge-making than the common holly, but it is very slow growing from seed, and rather expensive to buy as good-sized plants. Should holly be used, it is best planted in late April or May, or in October. In spring, when the buds begin to show growth, is one of the best times to move hollies.

Box also makes a fine hedge if of moderate size up to 5 feet, and it does not require much pruning. The usefulness of the common and copper beeches for hedges is well known and needs no further mention.

Ribes, Sambucus, and Rosa spp. The Flowering currant, *R. sanguineum*, and *S. racemosa*, the Red-berried elder, both make good hedges and are fast growing. The Sweet briar, *R. rubiginosa*, makes a hedge, but tends to die out in patches after a few years.

Pyracantha spp. The various species of *Pyracantha* have been found to make fine hedge plants. The genus is closely allied to *Cotoneaster* and *Crataegus*, and differs from the last named in being evergreen and in the leaves being entire or toothed and never lobed. *P. angustifolia* is a native of West China and is of a dense spreading bushy habit. The branches are usually horizontal, and the leaves, which are mostly entire except for a few teeth near the apex, are covered with a grey felt. The flowers are white and the fruit is orange-yellow when ripe, and usually hangs on till the following spring. It is easily propagated by cuttings inserted in an open frame which can be planted out at 1 year, and will soon form a compact hedge. Its dull grey leaves make the hedge very attractive. Pruning twice a year encourages late growths which usually get cut by hard frost. It soon recovers when growth starts again and no trace of the damage persists. *Pyracantha yunnanensis* is closely related to

P. Gibbsii, but is more spiny and less downy when young. This shrub will grow 12 feet or more high. It differs from *P. Rogersiana* in the shape of the leaves, which are all of an oblanceolate shape with broad, rounded, coarsely shaped ends. The red fruits are smaller than those of *P. Gibbsii*, of a lighter shade, and later in maturing, although the two may be connected by intermediate forms. It can be propagated by cuttings or seeds and is perfectly hardy, frost having no effect on it. It will form a very fine compact hedge and is a shining bright green in colour, which affords a fine contrast to the grey-green of *P. angustifolia*. The other species of *Pyracantha* should prove just as useful as *P. yunnanensis*, for very small botanical differences separate the various species from one another.

Cotoneasters. Cotoneasters are a fine genus and many of the species are tall, robust growing, and usually evergreen or semi-evergreen. The most common species used for hedges is *C. Simonsii*, a semi-evergreen shrub of erect, stiff habit which will grow to a height of 12 feet. It requires to be pruned hard to keep it in shape. It is also very pretty in winter with the scarlet fruit which it produces in great abundance. *C. salicifolia* is an evergreen shrub with long spreading branches and leaves that are 2–4 inches long. The flowers are small in dense, woolly corymbs, and the fruit is bright red and about a quarter of an inch in diameter. This species makes a fine hedge and seems to thrive with pruning. It is best pruned twice a year, the second pruning being done in September. This shows off the corymbs of red fruits which, mingled with the shining green leaves, makes the hedge very decorative. There is no reason why other Cotoneasters should not be tried as hedge plants. *Cotoneaster frigida* is one of our prettiest species. It is evergreen with leaves 3–6 inches long and corymbs of white flowers. The real beauty of this plant is in its fruit, because it usually has a mass of red berries in autumn. It is very hardy and seems to thrive anywhere. *Cotoneaster lactea* is another very hardy and easily grown plant. The leaves are more rounded than *C. salicifolia*, and not so long. It produces abundant small red fruits which are rather later in ripening than most of the other Cotoneasters, and they hang on to the plant for a long time. It is a vigorous grower and will reach a height of 10–12 feet. There is no doubt that many more of the newer Chinese species would make fine hedges. *C. Harroviana*, *C. Wardii*, *C. glaucophylla*, and *C. turbinata* are all fine, strong growing, hardy species which would make first-class hedge plants. Cotoneasters are usually best grown from seed, which they produce in great abundance. The fruit should be gathered and placed in moist sand for the winter and then sown in early spring.

Escallonia spp. Escallonia is a genus containing some very fine flowering shrubs, and with the exception of *E. macrantha* the best to use for hedge-making are the hybrids. *E. macrantha* is not too hardy, being a native of the island of Chiloe. It is a pretty evergreen shrub with leaves up to 3 inches long and bright rosy red flowers. In the milder districts it is greatly used for hedges. A hardier and very fine plant, however, is *E. edinensis*. This hybrid was raised at Edinburgh and is a cross between *E. rubra* and *E. virgata*. It

is very free flowering, the thin arching branches being wreathed from end to end with pretty pink flowers during the summer. This will make a very fine ornamental hedge up to 8 feet high. Pruning should be done with secateurs and after flowering. By cutting out the older side growths and shortening back some of the longer ones this will save the flowering display for the following season, which would be spoiled if it is pruned hard with a pair of shears. This *Escallonia* can be easily grown from cuttings taken in late summer and placed in an open frame. It may be interesting to say here that the writer inserted cuttings which had been left overnight in a solution of Hortomone A, and also cuttings not so treated. The former were by far the most successful, the result being a much stronger and better rooted plant in less time. Many of the other *Escallonia* hybrids could also be used in the same way as *E. edinensis* for hedges.

Berberis spp. Berberis is another genera which can also be used for flowering hedges. *Berberis Darwinii*, a fine evergreen shrub of dense habit, will grow up to 12 feet high. It is very attractive in April and May when laden with its orange-yellow flowers, which it bears in great profusion. It can easily be propagated from seed. *Berberis stenophylla*, a hybrid between the last-named and *B. empetrifolia*, is also another evergreen shrub with golden yellow flowers. This will also grow up to 12 feet high and is very hardy. This is best propagated from cuttings, as seed may not come true, usually reverting to one of the parents. Another *Berberis* that has been used for a hedge is *B. pruinosa*, an evergreen shrub that will grow 8 feet or more high. The leathery leaves are in tufts three to five in number, and the yellow flowers are solitary, followed later with black fruits covered with a whitish bloom.

Some of the deciduous species can also be used, such as *B. Thunbergii*, which makes a very pretty hedge, especially in the autumn, with its fine red berries and brilliantly coloured foliage. There is no doubt that many of the other species and hybrids of *Berberis* could be tried, for there are many to pick from both evergreen and deciduous. They, however, are best grown from seed and planted out when young, because they do not stand moving unless they have been transplanted every year.

Rhododendrons. The *Triflorum* and *Heliolepis* series of Rhododendrons also make fine ornamental hedges. Most of the species are evergreen and will stand a fair amount of sun and wind exposure. In the *Heliolepis* series there are *R. desquamatum*, *R. rubiginosum*, and *R. heliolepis*. All are evergreen and hardy and have aromatic foliage. They are usually very floriferous with mauve to rose and rosy lilac-coloured flowers. In the *Triflorum* group there is *R. yunnanense* with white flowers spotted with red, and make a very pretty hedge. *R. Davidsonianum* with pink flowers and red spots, *R. Augustinii* with different shades of blue flowers, or *R. pseudoyanthinum* with purple flowers, are only a few that could be tried. All these can be grown from seed which would produce a plant of 2–3 feet in 3 years' time. *R. praecox*, a hybrid between *R. dauricum* and *R. ciliatum*, also makes a very showy hedge in early spring, but this has to be grown from cuttings.

Conifers. Conifers can also be used, and one of the hardiest is the Lawson cypress. Grown from seed, it stands transplanting, so that plants of a good size can be used. A different tale is told if one tries *Cupressus macrocarpa.* To get the best results it is best reared in pots because it is intolerant of transplanting. For favoured localities it will make a fine hedge in a very short time, but it cannot be recommended for general use like the Lawson cypress. The Nootka cypress, *Chamaecyparis nootkatensis*, is another very hardy conifer. It is a fairly rapid grower and does quite well in any kind of soil. The Douglas fir has been used for hedges, but it is not to be recommended. Some of the *Thuya* spp. give better results. *Thuya plicata* is one of the best and will stand a fair amount of pruning. This has proved to be a fine hedge plant. Closely allied to it is *T. occidentalis*, which has also proved useful. It is of slower growth, however, and is not so decorative as the *T. plicata.* Both species like a moist loamy soil and are best raised from seed. In America, Junipers, spruce, larch, and *Retinosporas* are used for hedges with good results and there is no reason why Junipers and *Retinosporas* should not be tried here. Scots pine was extensively used for hedges some 50 years ago in the Breckland in Norfolk and Suffolk, but is not to be generally recommended.

It will be seen, therefore, that many plants can be used for hedges. It greatly adds to the attractiveness of a nursery if a variety of hedging plants have been used rather than adherence to the common species. One advantage in using species for hedges that are not being raised commercially in the nursery is that the risk of pests or diseases spreading from hedge plants is eliminated. The question of expense need not arise, because the enterprising forester can always pick up some seed or berries from different sources and grow the plants himself. Practically all those mentioned are fairly easily grown from seed or cuttings, and most have already been found to make good hedges and are well worth further trial.

OBSERVATIONS ON SPIRAL GRAIN IN THE WOOD OF *PINUS LONGIFOLIA*, ROXB.

(*Being a study of the relation of the pitch of the spiral grain in the wood of* Pinus longifolia *to rate of radial growth, tracheide length, and micellar pitch*)

BY P. MISRA

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INTRODUCTION.

A VERY complete account of the phenomena of spiral grain in the wood of Conifers has been given by Champion (3, 4) with particular reference to the phenomenon as seen in the Indian Chir Pine, *Pinus longifolia*.

All observers (2, 7) seem agreed that the direction of the spiral is usually constant in a given species, and, as in *Pinus longifolia*, the usual direction is that of a left-handed spiral (in the English sense).

Champion states that the direction of the twist may be reversed in very old timbers, an observation that has also been made in other species. A point of interest is that the twist is never stated to occur in the 1st-year wood in any part of the stem, although it may develop in the 2nd-year wood of seedlings. It may be of significance in this connexion that the 1st-year ring of wood, even in horizontal branches, is never at all excentric, although all later years in such branches usually show markedly greater radial depth on the lower side of the branches. There are, however, so far as the author is aware, no observations upon the relation of the spiral grain to the rate of radial growth of the wood or to other features of tracheide structure. The observations that follow suggest, however, that the radial growth, tracheide length, and even the pitch of the cellulose micelles in the tracheides are all features which show significant correlation with this phenomenon of spiral grain.

MATERIAL, METHODS, AND OBSERVATIONS.

The material of *Pinus longifolia* used in these investigations had been sent from Almorah, U.P., India, in 1934, through the kindness of Mr. H. G. Champion, Imperial Forest Institute, Dehra Dun, to Professor J. H. Priestley of Leeds University, under whose guidance the work was taken up. Each piece of wood sent was about 1 foot long and some 4–5 inches in diameter, each piece from a different stem with pronounced twist in grain.

Microscopical preparations, transverse, radial-longitudinal, and tangential-longitudinal sections showed no indication of any unusual feature of the wood, any abnormal inclination of the fibres not being revealed without an axis of reference. It was then decided to measure the angle between the

inclined fibre and the vertical line. A straight block of wood was stripped of its bark and turned on a lathe so that it was perfectly cylindrical about its pith line. A number of disks were then cut from the cylinder in the lathe, care being taken to make transverse surfaces exactly perpendicular to the long axis of the block, so that when the disk is placed on a horizontal plane the surface of the wood and also the axis of the stem will be vertical. The disk was then mounted on a plane glass surface, which was strictly horizontal, and the inclination of the tracheides from the vertical read on a horizontal microscope, cross-wires in the eyepiece of which were first focused on a silk plumb-line on the face of the disk and then the vertical cross-wire laid parallel with the tracheide direction, the necessary change of angle being registered on the graduated circular collar on the tube of the microscope.

By gradually rotating the wooden disk it was found that the inclination varies from a maximum gradually to a minimum approximately on the opposite side of the cylinder. Four diameters, each at an angular distance of 45° from the other, were drawn on the transverse surface of the disk, dividing it into octants. The inclination of fibres on the circumference of the cylinder in each octant was measured and noted. In some of the octants the early wood of the 7th year's ring was present at the circumference and in others the late wood of the 6th year's ring. The 7th ring was chipped off at right angles to the diameter with the help of a sliding microtome, the utmost care being taken to make the cut tangentially to the disk. Then the inclination of the fibre in the late wood of the 6th ring in all the octants was observed and recorded. It may be noted here that the inclination of all the fibres in the field is not the same, but the angle made by the majority of the fibres in the field has been carefully observed and taken. The readings may be regarded as correct with an experimental error of $\pm 0{\cdot}5$ degrees. Tangential strips were then cut off at right angles to all the diameters by the sliding microtome in all octants until a very small portion of the early wood of the 6th ring was left. Then the inclination of the fibres in that region in all the octants was observed and recorded. In this way the inclination of fibres in the late and early wood of all earlier rings in all the octants was observed and recorded. The results are given in Table I.

The following observation may be made from the readings in this table:

1. The fibres begin twisting at the beginning of the 3rd year's growth or a little earlier, when the inclination is very small, but it increases quickly so that in the late wood of the same year it is quite considerable. It goes on increasing steadily till the end of the 5th year's growth, after which it may fluctuate or increase slightly.

2. The inclination of fibres in certain octants is less than that of fibres in other octants from the late wood of the 3rd year's growth onwards, and the difference has reached its maximum in the 5th year's growth. This relationship appears to be constant in all the later years' growth, octants 2 and 3 possessing least inclination and octants 6 and 7 possessing the greatest inclination.

TABLE I. *The inclination in degrees of twisted fibres*

Plant 1, Disk 1.

	Annual Rings.									
	2	*3*		*4*		*5*		*6*		*7*
Octants.	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*	*Early.*
1	0	2	5	8	9·5	9·5	10	10·5	10·5	10·5
2	0	2	5	8	10	9·5	9·5	9·5	10	9·5
3	0	2	5	8	9	9	9·5	10	10	..
4	0	2	6	9	10	10·5	11	10·5	11	11
5	0	2	6·5	9	10·5	11	12	12	12·5	12
6	0	2	7·5	10	11·5	11·5	12·5	13	13	12·5
7	0	2	7	10	11·5	12	13·5	13·5	13·5	12·5
8	0	2	6·3	9	10·5	10·5	11·5	11·5	11	11·5

It was observed that the thickness of a ring is not the same in all the octants. In certain octants the thickness of most of the rings was constantly greater than in other octants. An attempt was made, therefore, to record the thickness of a ring in an octant and the inclination of the fibres of that ring in the same octant. A fresh wooden disk of the same plant (Plant 1, Disk 2) was taken for the purpose and four diameters were drawn on its transverse surface, dividing it into octants. The thickness of each ring of wood was then

TABLE II. *Total thickness of secondary wood in mm. and inclination of twisted fibres in degrees*

Plant 1, Disk 2.

	Annual Rings.									
	2	*3*		*4*		*5*		*6*		*7*
Octants.	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*	*Early.*
1 Th.	3·90	7·57	8·08	10·83	11·30	13·48	13·87	15·54	15·94	16·94
In.	0	2·2	8·5	11	12	12	12·5	12·5	12·5	12·5
2 Th.	3·80	7·58	7·91	10·44	10·88	13·13	13·48	14·90	15·29	16·31
In.	0	2·5	7	10	12	12	12·5	13	13	13
3 Th.	3·59	7·41	7·71	9·98	10·54	12·83	13·14	14·94	15·22	15·96
In.	0	2·2	7	9·8	11	11	12·8	13	13	13
4 Th.	4·04	7·33	7·63	10·25	10·64	12·96	13·29	15·36	15·62	16·60
In.	0	2	7	9	11	10	10·3	11·5	11·5	12
5 Th.	4·14	7·34	7·72	10·53	10·79	13·93	14·24	15·96	16·32	17·24
In.	0	2	6	9	10·5	10	10·3	10·5	10·7	11
6 Th.	4·07	7·70	8·04	11·09	11·41	15·04	15·53	17·75	18·00	..
In.	0	2	7	9	10·7	10	10·3	10·5	11	..
7 Th.	3·99	7·69	8·07	11·12	11·53	14·75	15·34	17·62	18·00	..
In.	0	2·5	8·3	10·2	11·2	10·5	10·8	11	11·5	..
8 Th.	4·12	7·77	8·09	11·05	11·44	14·20	14·53	16·80	17·23	..
In.	0	2·5	8·5	11	11·2	12	12	12	12	..

measured along each of these diameters, using the same cathetometer. The reading could be taken with precision up to a hundredth of a millimetre from the vernier attachment. By the process already mentioned for Disk 1, the angle made by the inclined fibres in the early and late wood of each ring in each of the octants was also measured and recorded. Table II gives the result of the observations.

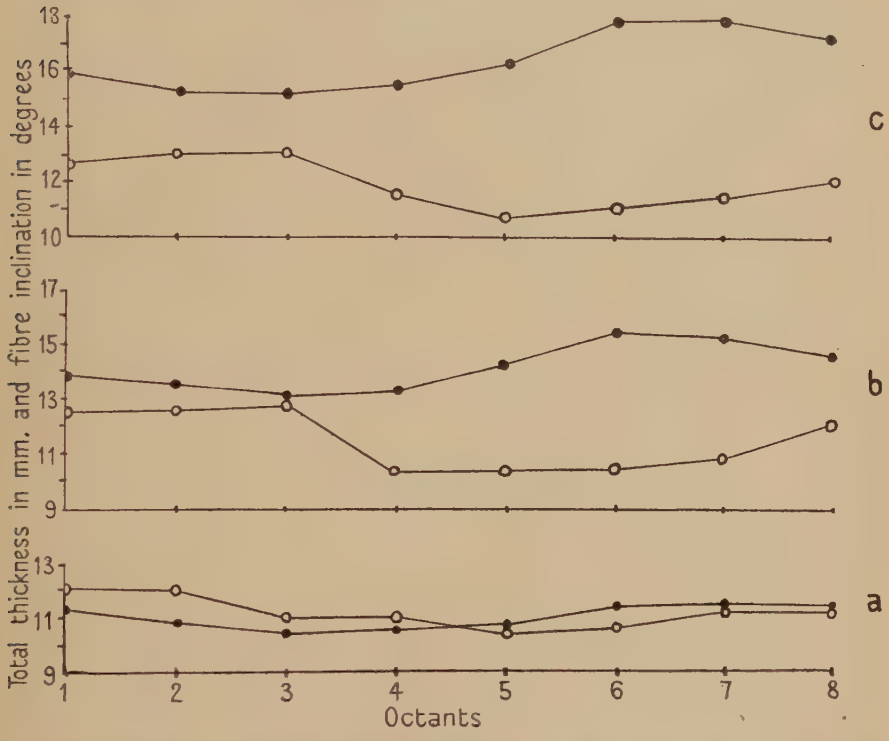

FIG. 1. Variation of inclination inversely with the thickness of the ring. (*a*) 4th ring late wood, (*b*) 5th ring late wood, and (*c*) 6th ring late wood. ●, thickness curve; ○, inclination curve.

If 0·5 degree be taken as correction for error of judgement in respect of inclination measurement and 0·1 mm. in respect of thickness measurement, then the small differences in thickness and inclination in the octants are insignificant up to the end of the 3rd year's growth. It is only in the 5th ring and the 6th ring that the difference is striking. If radial breadth and inclination are plotted for rings 4, 5, and 6, as in Fig. 1, it will be seen that, as the thickness goes on increasing from octant to octant in any individual ring, the inclination goes on decreasing, and vice versa. There seems to be a little drift in the inclination curve towards the left, as probably the fibres, the inclinations of which were measured, were not in the same line as the diameter in which region the thickness of the ring had been measured. In subsequent

investigations care has been taken to measure the inclination of the fibre in the region where the thickness has been determined (cf. Fig. 6).

The last segments that were cut off by the sliding microtome from this wooden disk (Plant 1, Disk 2) from each of the different rings in the octants 2 and 6 had been trimmed free from wood of other rings and preserved for measuring the pitch of 'micelles' or of the cellulose chains in the tracheide walls. The segments were taken just near the place where the inclination of the spiral tracheides was measured. The last layers of the late wood were avoided, as the distinction between the radial and tangential walls of tracheides is not clear in that region. Octants 2 and 6 were chosen because the thickness and inclination curves have almost reached maximum and minimum points in those octants and they are diametrically opposite. The methods and procedure have been those used by Dr. R. D. Preston (11). The segments were macerated in 5 per cent. chromic acid until disintegration into tracheides just occurred on shaking with glass beads, when the acid was decanted and replaced by water. The washing was repeated five or six times. A suspension of macerated cells was allowed to flow over a slide previously thoroughly cleaned in alcohol and covered with a thin layer of albumen fixative. The water was evaporated at a temperature of about 25° C., the glycerine of the fixative removed by alcohol, and the slides were heated at 60° C. until the

TABLE III. *The inclination of cellulose chain or 'micelles' in degrees on radial and tangential walls in the tracheides of twisted pine, in relation to the axis of the tracheides.*

Plant 1, Disk 2.

	Tangential wall.						*Radial wall.*					
	Octant 6.			*Octant 2.*			*Octant 6.*			*Octant 2.*		
Ring.	*Min.*	*Max.*	*Mean.*	*Min.*	*Max.*	*Mean.*	*Min.*	*Max.*	*Mean.*	*Min.*	*Max.*	*Mean.*
2–E	..	..	..	24	64	46·3 ±1·5	..	..	..	44	78·5	58·7 ±1·1
L	34	65	50·5 ±1·07	35	58	47·75 ±0·9	39	74	56·3 ±1·3	39·5	65	52·5 ±0·9
3–E	38	59	47·0 ±1·1	33	57	45·7 ±1·1	43	64	53·3 ±0·8	40	70	54·7 ±1·1
L	30	49·5	39·93 ±1·2	27	56	39·7 ±1·2	36	61	49·4 ±1·4	32	69	48·7 ±1·2
4–E	23	52·5	35·6 ±1·0	23	47	33·45 ±1·0	35	64	45·7 ±1·8	30	57	41·05 ±1·4
L	20·5	40	29·86 ±0·75	20	43·5	32·4 ±0·9	34·5	61	43·75 ±1·1	30·5	54·5	39·1 ±0·8
5–E	22·5	40	34·7 ±1·2	19·5	37·5	26·44 ±0·9	34·5	51	43·1 ±0·8	29	53	37·1 ±1·0
L	20	37	28·3 ±1·25	18	33·5	25·5 ±0·8	27·5	55	42·5 ±1·4	27	51	36·0 ±1·5
6–L	15	32	25·0 ±0·75	14	19	22·0 ±1·5	22	57	35·5 ±1·2	19	47	29·8 ±1·4

fixative was hard. The slides were then shaved with a sharp knife, and as most of the tracheides were lying parallel to the surface of the slide, in most of them one of the longitudinal walls was completely or partially removed. Then the slides were mounted in Canada balsam in the usual way. The long axis of the tracheide furnishes the co-ordinate axis to which the inclination of the micelles is referred. Tips of cells, bordered pits, and parts containing various deformations were avoided. A Zeiss polarizing microscope was used.

About fifty readings were taken from tracheides taken respectively from early and late wood of octants 2 and 6 from the 2nd to the 6th annual ring. In order to present some idea of the variation of the readings amongst themselves, the standard variation and probable error have been calculated along with the mean in each case [Fisher (5)]. Table III records the results.

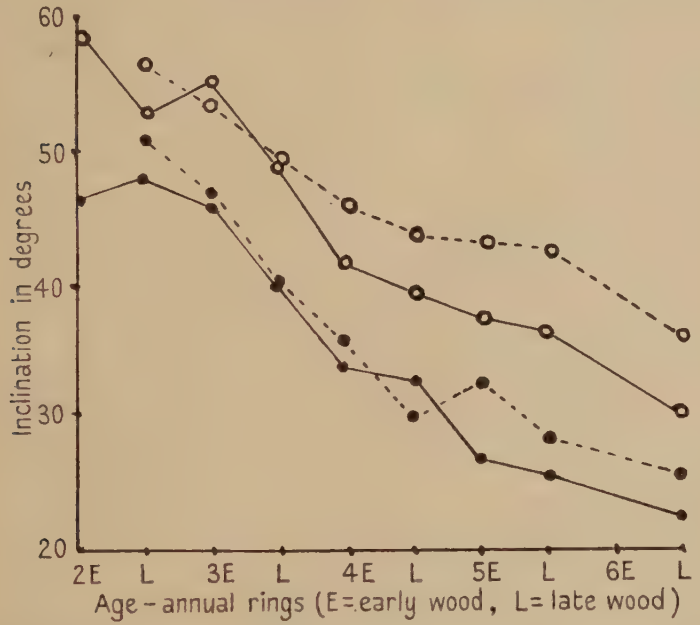

FIG. 2. Variation of inclination of cellulose chain with age as well as with two different octants. o, radial wall; ●, tangential wall. ———— Octant 2; - - - - - - - Octant 6.

As will be seen from Table III and the accompanying graphs (Fig. 2), the steepness of the cellulose chain goes on increasing as the age increases and, as usual, the inclination in the tangential wall is greater than that in the radial wall. Up to the 3rd year's growth the inclination of the micelles on the radial walls is practically the same for both the octants 2 and 6 because the difference in their readings is less than twice the sum of their probable errors and hence insignificant. The inclination of micelles in the tracheides of octant 6 have steepened less from the beginning of the 4th year's growth, whereas it has steepened comparatively more for the tracheides of octant 2. The difference between their readings is very pronounced and quite significant in the 5th

and the 6th rings. The difference in the 4th ring early wood is apparent though not significant. From the following table (Table IV) and graph (Fig. 3) the correlation between the ring thickness, inclination of the course of tracheides (fibres), and the inclination of cellulose chain on the radial wall of the tracheides in relation to its own axis may be seen.

TABLE IV. (A) *Total thickness of secondary wood in mm.* (B) *Inclination in the course of the tracheides in degrees.* (C) *Inclination of the cellulose chain on the radial wall of the tracheides in degrees.* (D) *Thickness of each ring in mm.*

Plant 1. Disk 2.

		Annual Rings.									
		2		*3*		*4*		*5*		*6*	
Octants.		*Early.*	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*	*Early.*	*Late.*
(A)	2	..	3·80	7·58	7·91	10·44	10·88	13·13	13·48	14·90	15·29
	6	..	4·07	7·70	8·04	11·09	11·41	15·04	15·53	17·75	18·00
(B)	2	..	0	2	7	10	12	12	12·5	13	13
	6	..	0	2	7	9·5	10·7	10	10·3	10·5	11
(C)	2	58·7 ±1·1	52·5 ±0·9	54·7 ±1·1	48·7 ±1·2	41·0 ±1·4	39·1 ±0·8	37·1 ±1·0	36·0 ±1·5	..	29·8 ±1·4
	6	..	56·3 ±1·3	53·3 ±1·3	49·4 ±1·4	45·7 ±1·8	43·75 ±1·1	43·1 ±0·8	42·5 ±1·4	..	35·5 ±1·2
(D)	2	3·40	0·40	3·78	0·33	2·53	0·44	2·25	0·35	1·42	0·39
	6	3·69	0·38	3·63	0·34	3·05	0·32	3·63	0·49	2·22	0·25

Frey (6), using the theory of mixed bodies as developed by Wiener (12), and Meyer and Mark (9), came to the conclusion that the cell-wall consists of long, thin, rod-like aggregates whose diameter was small compared with the wave-length of light, i.e. 'micelles' of Nägeli. The micelles have a three-dimensional crystal nature and collect together, taking the form of fibrils running spirally round an elongated cell. As the cells elongate, the inclination of the spiral (cellulose chain) often steepens, making a progressively smaller angle with the axis of the cell [Preston (11)].

From Table IV it is quite clear that the tracheides get longer from year to year as radial growth proceeds. In octants 2 and 6 the inclination of the micelles in a year is nearly the same up to the 4th-year early wood, the difference being statistically insignificant. It is interesting also to note that the radial extension of secondary wood in the 2nd and 3rd years' growth is nearly the same, as also the inclination of spiral tracheides to the axis of the plant, in octants 2 and 6. The radial growth in the early wood of the 4th year's ring is appreciably greater in octant 6 than in octant 2. The effect of this variation has found expression in the late wood of the same ring in the significant difference of micellar pitch between the tracheides of both these octants, as also in the appreciable difference in the inclination of spiral grain in relation to the axis of the plant. It has already been observed from the figures of Table II that, in any particular ring, if there is more radial growth on any side the inclination of the spiral grain in relation to the axis of the plant

on that side is less than on the side where there is less radial growth. From Table IV it is found that the micellar pitch steepens less on the side where there is more radial growth. Further observations in the 5th and the 6th rings confirm this conclusion.

So far, the figures and the curves that have been compared pertain to the absolute value of the ring thicknesses, fibre inclinations, and micellar pitches

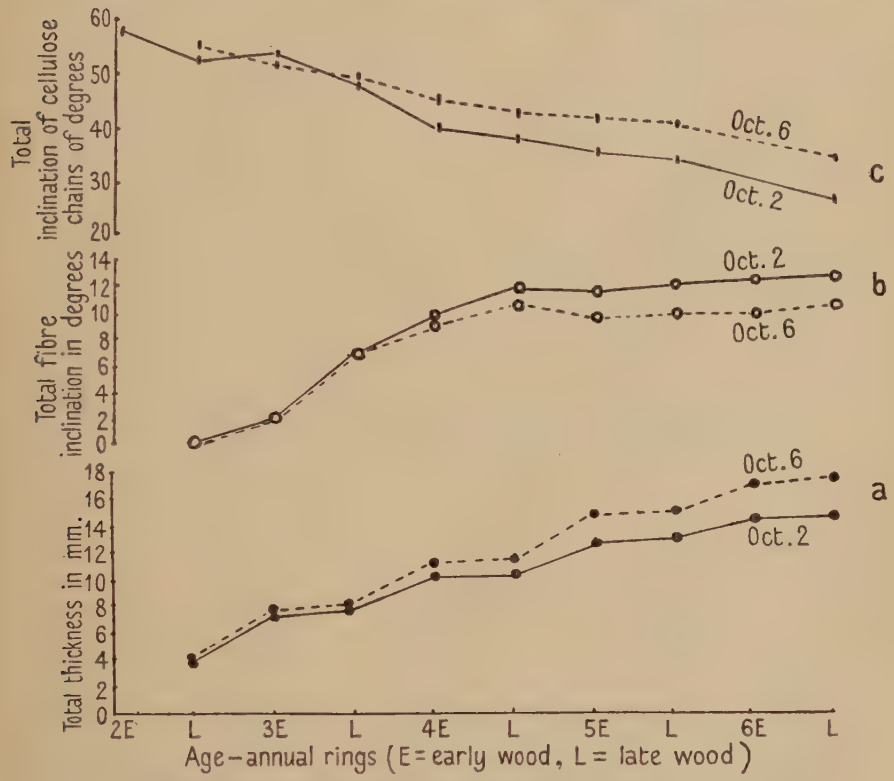

FIG. 3. (A) Thickness, (B) fibre-inclination, (C) micellar-pitch curves. ———Octant 2; - - - - - Octant 6.

in both the octants 2 and 6. In the following table (Table V) the difference between the ring thickness, fibre inclination, and micellar pitch in the tracheide wall throughout octant 2 and octant 6 (O_2–O_6) and the rate at which these differences vary from ring to ring are given. The first three columns of this table have been calculated from Table IV, and the rate of variation has been calculated by subtracting the preceding figure from the figure for the region in question.

In Fig. 4 the thickness difference curve, fibre-inclination difference curve, and the micellar-pitch difference curve are drawn together, and it is interesting to note that the courses of the thickness difference curve and the micellar-pitch difference curve vary in the same sense from early to late wood and

Plant 1, Disk 2. TABLE V

Ring.	*Difference between O_2 and O_6.*			*The rate of variation.*		
	Thickness.	*Fibre inclination.*	*Micellar pitch.*	*Thickness.*	*Fibre inclination.*	*Micellar pitch.*
2–E	−0·29	0	..	−0·29	0	..
L	−0·27	0	−3·8	+0·02	0	−3·8
3–E	+0·15	0	+1·4	+0·42	0	+5·2
L	+0·14	0	−0·7	−0·01	0	−2·1
4–E	−0·52	+0·5	−4·65	−0·66	+0·5	−3·95
L	−0·40	+1·3	−4·65	+0·12	+0·8	0
5–E	−1·38	+2·0	−6·0	−0·98	+0·7	−1·35
L	−1·52	+2·2	−6·5	−0·14	+0·2	−0·5
6–E	−0·80	+2·5	..	+0·72	+0·3	..
L	−0·56	+2·0	−5·7	+0·24	−0·5	+0·8

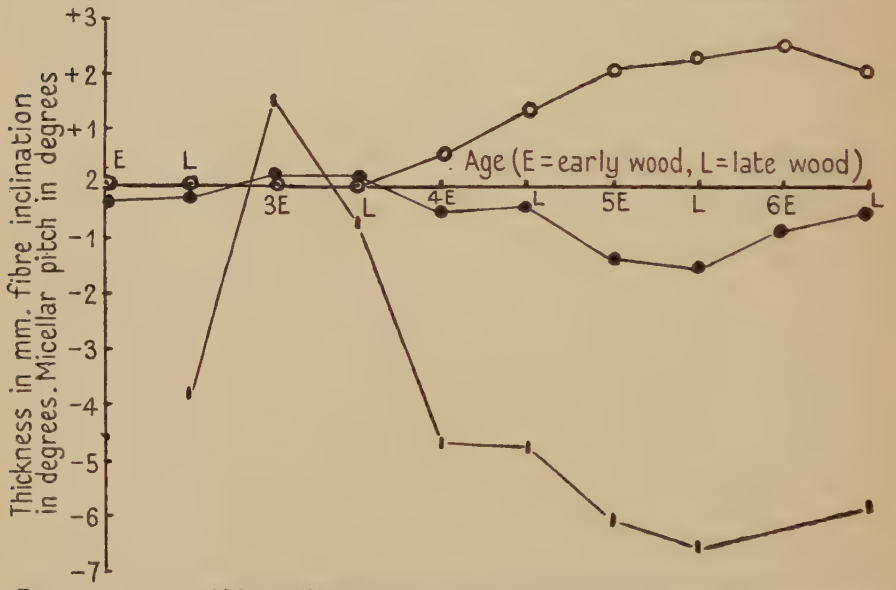

FIG. 4. —●— thickness difference curve; —○— fibre-inclination difference curve; —|— micellar-pitch difference curve.

from ring to ring, whereas the fibre-inclination difference curve behaves in just the reverse manner.

In Fig. 5 the rate at which these differences vary from early to late wood and from ring to ring have been separately plotted and three curves drawn and the same correlation is found.

The micelles steepen more, i.e. the angle between the fibril and the long axis of the tracheide becomes less, as the tracheides elongate. So it may be said that the cells elongate less on the side of an annual ring where there is more radial growth. Hence a third disk of the same plant was taken, octants were marked, thickness of rings noted, and trimmed chips of wood from each

octant O_1 to O_8 of the 5th ring only, just at the place where the inclination of spiral fibres was measured, were taken. The chips were macerated in 5 per cent. chromic acid for 48 hours and washed thoroughly in many changes of water. They were then washed in distilled water and treated for 6 hours with 2·5 per cent. iron-alum solution. After that they were washed with distilled water and then stained with 0·5 per cent. haematoxylin solution for

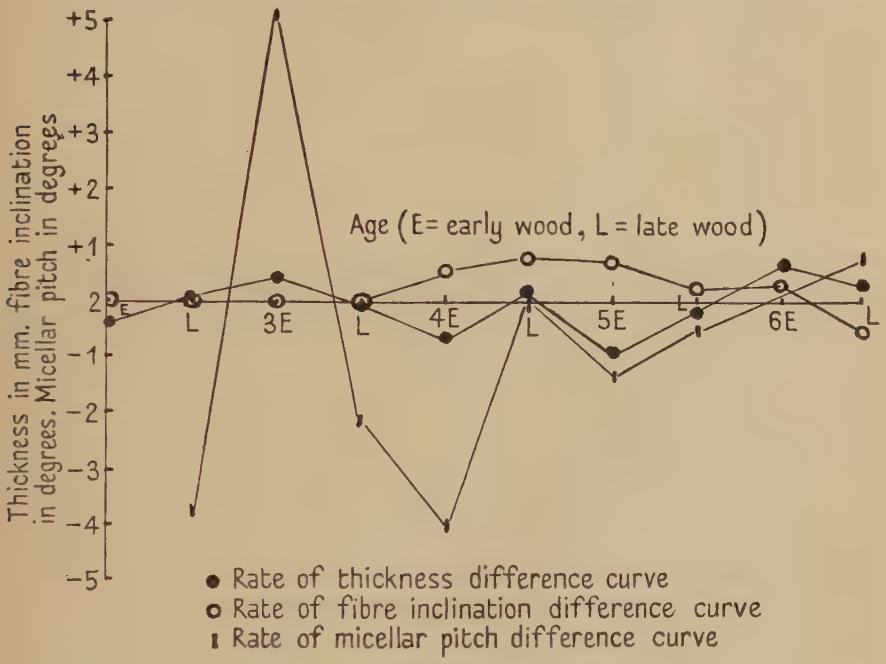

FIG. 5.

3 hours. They were then washed thoroughly with tap-water. Each strip was then laid on a slide previously smeared with albumen fixative, crumbled in water, and the tracheides arranged in parallel rows. The slide was then dried at a temperature of about 30° C. for 5 to 6 hours. The slide was passed from 90 per cent. to 70 per cent. alcohol and from 70 per cent. to 50 per cent. alcohol, and finally into water. Then a few drops of 50 per cent. glycerine in water were placed on a slide and a cover-glass was placed over it. The edge of the cover-glass was sealed with German black. The length of 50 tracheides was measured by an eyepiece with screw micrometer. The average was calculated and probable error determined by the usual method [Fisher (5)]. The following table (Table VI) gives the result of the observations.

From this table it can be seen that the ring thickness in octants 3, 4, and 5 is greater than that in octants 1, 2, 6, 7, and 8. The inclination of spiral fibres in octants 1, 2, 6, 7, and 8 is greater than that in the other octants, and the tracheides of octants 1, 2, 6, 7, and 8 are longer than those of the others.

In the case of horizontal branches of Conifers where there is excentricity in

Plant 1, Disk 3. TABLE VI

Octant.	*Thickness of wood in ring 4.*	*Inclination of spiral fibre in the early wood of ring 5.*	*Length of tracheides in early wood of ring 5, with probable error.*
	mm.	°	μ
1	3·01	12	2,525± 78·5
2	3·08	10·5	2,575± 87·0
3	3·20	9·5	1,996± 84·9
4	3·37	9·5	2,224± 91·9
5	3·51	9·0	1,950±100·0
6	3·14	10·5	2,714±114·3
7	3·11	11·0	2,676±123·0
8	3·10	11·5	2,882±103·0

the rings, Jaccard and Frey (8) have pointed out that the micellar pitch is steeper in thinner portions (upper side of the branch), because here the tracheides elongate more. Baranetzky (1) has also found in such softwood branches longer tracheides on the upper side where there is less radial growth.

To verify the results thus obtained a second plant sent from the same locality was taken and studied. The methods used were the same as in Plant 1. In the second plant, however, the excentricity was less than in Plant 1, and the variation in radial growth changed sides from year to year. The inclination of the fibre was higher on the whole and started from the middle of the 2nd ring. The total thickness up to the end of the rings in each octant and the inclination of the spiral fibres with relation to the plant's axis in the late wood of each ring in each octant is given in Table VII.

From Table VII and the accompanying curves (Fig. 6) it appears:

1. That the twisting of the fibres commences somewhere in the middle of the 2nd year's growth.
2. That the increase in the inclination of the fibres proceeds nearly equally in each octant, as also does the radial growth, with very little variation, up to the end of the 4th ring.
3. That in the 5th-year's growth octants 1, 7, and 8 have increased more in radial extension than octants 2 to 6. The inclination of spiral fibres has increased more in octants 2 to 6 in the late wood of the same year and in the early wood of the 6th year. So, as in Plant 1, it may be concluded that the twisting of the tracheide increases more on a side where there is less radial extension and less on a side where there is more radial extension in any particular ring. The same relation continues in the annual rings that follow.

The chips of wood that were cut off with the sliding microtome a little after the region of commencement of each ring, just on the line where the angle of inclination of the spiral grain had been determined, were preserved and trimmed to include the wood of that ring only. The shavings of octant 1 and octant 5, because they are opposite each other and show more variation,

TABLE VII. *Total thickness of secondary wood in mm., and inclination of twisted fibres in degrees*

Plant 2, Disk 1.

Octants.	*Annual rings.*							
	2	*3*	*4*	*5*	*6*	*7*	*8*	*9 (early)*
1 Th.	3·91	7·80	10·18	13·41	14·66	16·71	18·56	..
Incl.	4	11·5	12	12·2	13	13·5	13·3	13·5
2 Th.	4·00	7·94	9·94	12·03	14·08	16·00	18·12	..
Incl.	4	12	13·6	14	14	15	14·3	14·8
3 Th.	4·02	8·16	10·36	12·39	14·04	16·00	17·76	..
Incl.	4	12	13·8	14·5	15	15·2	15	15·2
4 Th.	3·92	8·00	10·25	12·37	13·98	15·71	17·45	..
Incl.	4	12	13·4	14·5	15·2	16·2	16·4	17·5
5 Th.	4·11	8·06	10·30	12·34	14·03	15·57	17·39	..
Incl.	4	12·3	13·4	15	15·6	16	16	16
6 Th.	3·83	7·68	10·11	12·32	14·16	15·88	17·60	..
Incl.	4	11·7	13·3	14·5	15·5	16	16	16
7 Th.	4·00	7·87	10·39	12·67	14·73	16·65	18·42	..
Incl.	4	11·5	13	13	13·5	15·2	15	15·5
8 Th.	3·89	7·73	10·46	12·68	14·73	16·80	18·54	..
Incl.	4	11·3	12	12·5	13·5	14	15	15·5

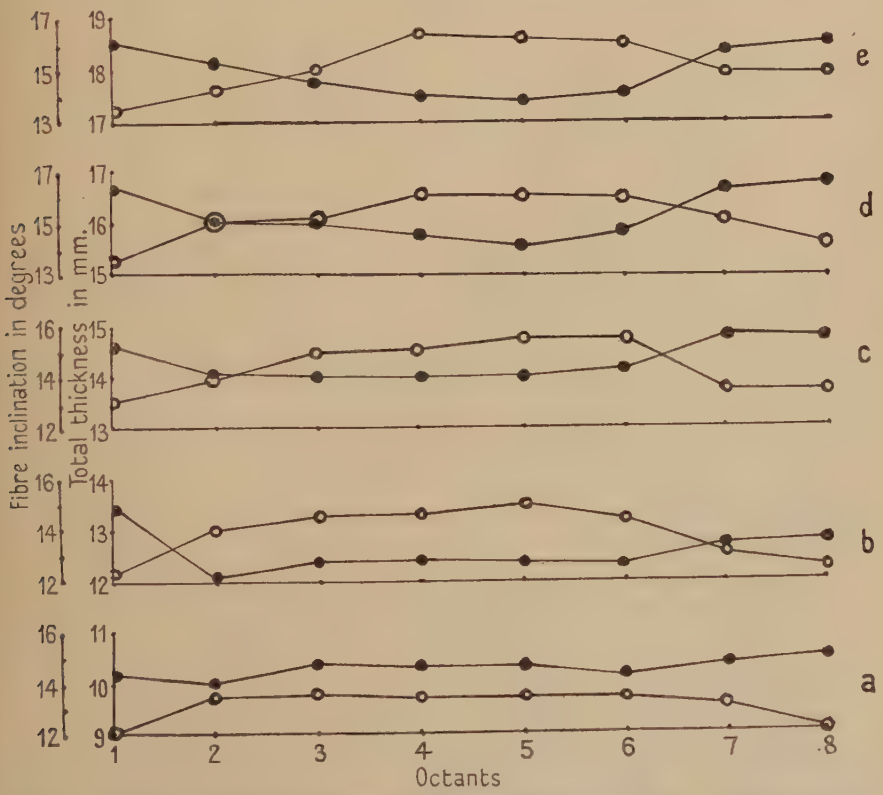

FIG. 6. Variation of inclination inversely with the thickness of the ring. ●, thickness curve; ○, inclination curve. (*a*) 4th ring, (*b*) 5th ring, (*c*) 6th ring, (*d*) 7th ring, (*e*) 8th ring.

were macerated and stained with Heidenhain's haematoxylin in the same way as in Plant 1, Disk 3. The length of 50 tracheides was measured in both octants in each ring from ring 2 to 9. The average length and probable error were worked out and tabulated in the following table along with the thickness of the individual rings and inclination of spiral tracheides of octants 1 and 5. The difference between these readings of octants 1 and 5 (O_1–O_5) also are given in the last three columns.

TABLE VIII

	Octant 1.			*Octant 5.*			*Difference O_1-O_5.*		
Annual ring.	*Thickness each ring.*	*Fibre incl.*	*Tracheide length.*	*Thickness each ring.*	*Fibre incl.*	*Tracheide length.*	*Thick-ness.*	*Incl.*	*Length.*
			μ			μ			
2–L	3·91	4	1,748± 65	4·11	4	1,806± 58	−0·20	0	− 58
3–E	..	8	2,312± 80	..	8	2,304± 88	..	0	+ 8
L	3·89	11·5	..	3·95	12·3	..	−0·06	−0·8	..
4–E	..	12	2,988±111	..	12·8	3,116± 89	..	−0·8	−128
L	2·38	12	..	2·24	13·4	..	+0·14	−1·4	..
5–E	..	12·2	3,170±106	..	14	3,300±109	..	−1·8	−130
L	3·32	12·2	..	2·04	15	..	+1·19	−2·8	..
6–E	..	12·3	3,102± 68	..	15·6	3,606±109	..	−3·3	−504
L	1·25	13	..	1·69	15·6	..	−0·44	−2·6	..
7–E	..	13·2	3,718±122	..	15·8	3,734±125	..	−2·6	− 16
L	2·05	13·5	..	1·50	16	..	+0·55	−2·5	..
8–E	..	13·5	3,838±128	..	15·8	4,170±128	..	−2·3	−332
L	1·85	13·3	..	1·86	16	..	−0·01	−2·7	..
9–E	..	13·5	3,826±162	..	16	4,544±112	..	−2·5	−718
E 2	..	13·5	4,112±197	..	16	4,364±117	..	−2·5	−252

Fig. 7 shows the curves for thickness difference, fibre-inclination difference, and tracheide-length difference between octant 1 and octant 5, and Fig. 8 shows the rate at which these differences vary from year to year. They have been worked out from the figures of the last three columns of Table VIII. During the 5th year and the 7th year there are gains in thickness in octant 1 which were measured at the end of those years and consequently plotted at 6E and 8E respectively on the graph. Hence there are two marked rises in the thickness curve at 6E and 8E. Synchronizing with it there are two marked falls in the inclination curve and the tracheide-length curve. At 7E there is a fall in the thickness curve. There is an upheaval in the fibre-inclination curve about here, and there is a rise in the tracheide-length curve at 7E.

All the pieces of stems belonging to four different plants that were sent from Almorah, U.P., India, were studied, and the same correlation between the ring thickness and the inclination of spiral tracheides was found. There was also a piece of stem having eight complete annual rings, showing very feeble twist in some octants and none in others and thus appearing straight grained. In this stem the radial growth and fibre inclination were nearly the same up to the end of the 4th year's growth. In the 5th year there was

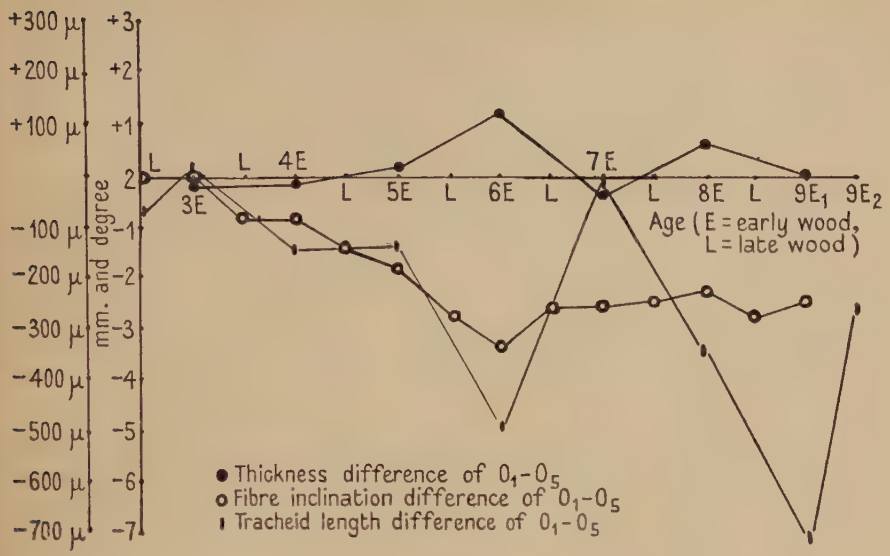

FIG. 7.

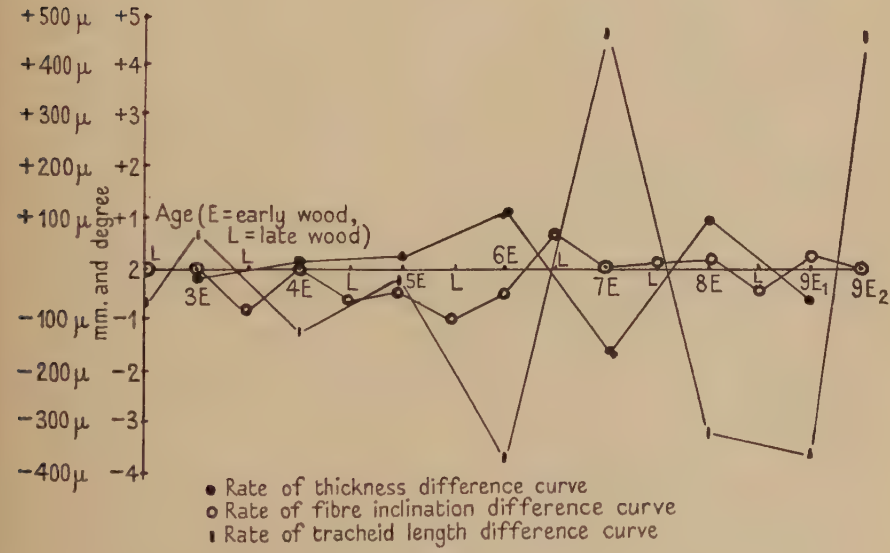

FIG. 8.

a very great excentricity, which caused a considerable fall in the angle of inclination of twisted fibres in those octants where there was greater radial depth. In subsequent years, when the excentricity reversed, the inclination went on decreasing slowly in other octants also till the end of the 8th year

when it became zero in those octants where the total radial depth was greatest and feeble for the other octants. The results of observation from the 3rd year to the end of the 8th year are tabulated below (Table IX).

TABLE IX. *Total thickness of secondary wood in mm., and inclination of twisted fibres in degrees*

Plant 3, Disk 1.

	Annual rings.					
Octants.	*3*	*4*	*5*	*6*	*7*	*8*
1 Th.	4·97	8·64	10·09	12·71	14·09	15·48
Incl.	6	6	6	5	5	4
2 Th.	5·13	8·75	10·68	13·02	14·32	15·45
Incl.	6	6	4	4	3	2·5
3 Th.	4·95	8·50	11·24	13·36	14·60	15·65
Incl.	4	4	2	2	1·5	0
4 Th.	5·25	9·04	12·58	14·72	16·00	17·01
Incl.	6	5·5	2	2	1·5	0
5 Th.	5·13	8·81	12·78	14·95	16·36	17·40
Incl.	6	4·5	2	2	2	0
6 Th.	5·28	9·15	12·27	14·56	16·04	17·40
Incl.	6	6	4	4	4	2
7 Th.	5·12	8·92	11·46	14·28	16·26	17·39
Incl.	7	7	6	5	5	3
8 Th.	5·08	8·68	10·53	13·43	14·85	16·00
Incl.	6	7	7	5	5	4

In this particular stem the inclination of tracheides, instead of increasing in octants of less radial growth as for Plant I, appears to remain the same and to decrease in octants of more radial growth, so that the plant which had undoubted spiral grain when young became nearly straight grained due to subsequent changing of sides of excentricity in the radial growth. An indication to this effect is also found in observations for Plant 2 in Table VIII. However, in all the plants so far examined the correlation between the ring thickness and the inclination of spiral grain remains the same, i.e. octants having greater radial depth possess less-twisted tracheides than octants having less radial depth.

SUMMARY AND CONCLUSION.

Rate of radial growth, inclination of the spiral grain to the vertical, micellar pitch on the tracheide wall in relation to its own axis, and tracheide length were studied in different octants of each year's growth, in four pieces of stems, each from a different plant of Chir pine (*Pinus longifolia*) with pronounced twisted fibre, sent from Almorah, U.P., India. The following correlations were observed in all of them.

(*a*) Excentricity in radial growth and the inclination of twisted fibres appear to be correlated with each other. In an annual ring octants having

more radial depth possess less-inclined tracheides than octants having less radial depth. A subsequent change in the rate of radial growth in excentric rings is linked with an inverse rate of change in the inclination of tracheides.

(*b*) Excentricity in radial growth shows correlation with the micellar pitch on the tracheide walls just as in the horizontal branches of other Conifers. The steepness of micellar pitch is greater on a side where there is less radial growth. The rate of change in micellar pitch, from ring to ring, appears to vary inversely with the rate of change of radial depth.

(*c*) The length of tracheides also is correlated with the excentricity of radial growth just as in the case of horizontal branches of other Conifers. Smaller tracheides are found in octants having greater radial depth, and longer tracheides are found in octants having less radial depth. A subsequent change in the rate of radial growth in excentric rings is linked with an inverse rate of change in the length of tracheides.

In conclusion, the author expresses his indebtedness to Professor J. H. Priestley for his guidance and valuable suggestions, and to Dr. R. D. Preston for his valuable help in the technique. He also wishes to thank Mr. H. G. Champion, I.F.S., for the material.

LITERATURE REFERENCES

(1) Baranetzky, J. (1901): *Flora*, lxxxix. 138–239.
(2) Braun, A. (1854): *Sitzungsber. d. K. Preuss. Akad. d. Wiss. zu Berlin*, pp. 432–84.
(3) Champion, H. G. (1925): *The Indian Forest Records*, xi. 1–70.
(4) —— (1930): *The Indian Forester*, lvi. 511–20.
(5) Fisher, R. A. (1932): *Statistical Methods for Research Workers*. Oliver and Boyd.
(6) Frey, A. (1926): *Jahrb. wiss. Bot.* lxv. 195.
(7) Hartig, R. (1895): *Sitzungsber. d. Akad. d. Wiss. zu München, Math.-phys. Kl.* xxv. 199–217.
(8) Jaccard, P., and Frey, A. (1928): *Jahrb. wiss. Bot.* lxviii. 844–66.
(9) Meyer, K. H., and Mark, H. (1928): I. *Ber. deutsch. Chem. Ges.* lxi B, p. 593.
—— (1929): II. *Z. phys. Chem.* B. 2, p. 115.
—— (1930): *Der Aufbau der hochpolymeren organischen Naturstoffe.*
(10) Nägeli, C. (1928): *Ostwald's Klass. exakt. Wiss.* ccxxvii.
(11) Preston, R. D. (1934): *Phil. Trans. R.S. London*, B, ccxxiv. 131–74.
(12) Wiener, O. (1912): *Abh. sächs. Ges. (Akad.) Wiss.* xxxii.

THE DEPLETION OF STARCH FROM TIMBER IN RELATION TO ATTACK BY *LYCTUS* BEETLES

IV. A THIRD EXPERIMENT ON THE GIRDLING OF STANDING OAK TREES

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INTRODUCTION.

THE results of two experiments already reported (1, 2) show that depletion of starch from the sapwood of oak can be brought about by certain methods of girdling the standing tree. At the same time, however, it is evident that this process for the production of *Lyctus*-immune timber apparently cannot be relied upon, since considerable variation in the rate of depletion was encountered. Before any final pronouncement can be made on the efficacy of the girdling treatment as a means of securing starch-free wood it is obviously necessary to discover if this variation is typical, whether any explanation can be found for it, and whether it can be reduced or avoided. The following experiment has, therefore, been undertaken to acquire information on these points, and this account of the method and results forms the fourth contribution to a series dealing with starch in timber and methods of causing its resorption.

MATERIAL.

Twenty standing oaks (*Quercus robur* L.), about 120 years of age, in Godshill Enclosure, New Forest, Hants, were girdled for this experiment, and two additional trees served as controls. The enclosure is an almost pure stand of even-aged oak with an undergrowth of holly and is in course of natural regeneration. No defoliation by the oak-leaf roller, *Tortrix viridana* (L.), had occurred here for many years, so that vitiation of the experiment by this caterpillar was unlikely. This particular wood also seemed well suited for the work, since full seed production had last occurred in 1935; only a partial crop was formed in 1936 and that in 1937 was very poor, so that it was reasonable to expect that some trees would seed during the course of the experiment and thus enable the effect of seed production on starch depletion to be assessed. The experimental trees were selected from those which had produced adequate regeneration and were due for felling in the near future. In selecting these trees regard was paid to differences in growth vigour as judged by crown size; twelve trees were chosen as being near the average in this respect, four others as weakly, and another four as markedly vigorous.

TREATMENT.

All the experimental trees were girdled at a point below the lowest main branch and all smaller branches below the girdle were removed. Three methods of girdling were employed. Four trees were dealt with as in the previous experiments of 1935 and 1937, a ring of bark approximately 6 inches wide being removed with an axe, and a groove $\frac{1}{4}$–$\frac{1}{2}$ inch deep then cut round the middle of the exposed wood by means of a V-shaped turnery chisel and a mallet, thus ensuring interruption in the longitudinal continuity of elements in the phloem and cambium. It was thought that this refinement might be dispensed with, provided reasonable care was exercised in removing all traces of inner bark, and accordingly a plain girdle only, i.e. exposure of the sapwood without grooving, was cut on twelve of the trees. On the remaining four trees a deep notch was cut round the middle of each girdle with an axe so as to expose the heartwood; by this means all the functioning channels for longitudinal conduction were severed. An indication had been obtained from the earlier experiments that time of girdling might affect the results, and for this reason the present treatment was performed on two separate dates, ten trees being dealt with on each occasion. Circumstances unfortunately prevented the first set of trees being girdled prior to the bursting of the buds, as in the 1937 experiment; the second set, however, were treated, as in the 1935 experiment, at the beginning of July. The general data on the trees is summarized in Table I.

The work was carried out in $9\frac{1}{2}$ hours by two men, one cutting the girdles and the other manipulating the ladder. The volume of timber below the girdles amounted to approximately 500 cubic feet and the labour charge, at 1 shilling per hour per man, to 19 shillings, equivalent to 0·45 pence per cubic foot.

The progress of starch depletion was followed by means of increment borings taken periodically from the north and south sides of each tree at breast height and also from just below the girdles. Observations were made at the same times on the condition of the foliage, seed production, epicormic branch development, and callus formation at the girdles.

RESULTS.

(i) *Effect of girdling on growth of trees.* The effect of girdling was shown first by those trees which had been deeply notched. The leaves turned brown about six weeks after treatment, and by 1 November, irrespective of the date of girdling, had nearly all fallen. On the same date there was no difference between plain girdled and shallowly notched trees, but in general the leaves were browner and fewer on those girdled on 30 May. The leaves on the controls were beginning to yellow, but none had been shed. Fresh growth of epicormic twigs, as was seen in the preceding experiment (2), was noted on the girdled trees, especially nos. 2, 3, and 5. Examination of the girdles on 16 January 1939 for signs of callus growth revealed very little activity in this direction. Many trees showed no callus formation, and the remainder only a few small growths

extending downwards for ½ inch or less from the bark above the girdle. Unfortunately, acorns were not produced by any of the trees during the 1938 season, consequently it was not possible to ascertain the effect of seed production on starch depletion; nor was it possible to see whether the girdling treatment would have influenced seed production.

TABLE I. *General data on experimental and control trees*

Tree no.	*Date of girdling.*	*Treatment.*	*Girth at 4 ft.*	*Length to girdle.*	*Volume to girdle.**	*Vigour class.†*	*Sapwood.‡*		
							Width.	*Annual rings per inch.*	*Width of last 3 annual rings.*
			in.	ft.	cu. ft.		in.		in.
1	30.v.38	Plain girdle	57	15½	23	Average	0·85	17	0·19
2		,,	61	17	28	,,	0·75	30	0·11
3		,,	60	15½	26	Vigorous	1·50	23	0·10
4		,,	70	16	36	,,	1·05	19	0·19
5		,,	59	16½	26	Weak	1·50	23	0·12
6		,,	53	15	19	,,	0·93	32	0·07
7		Shallow notch	55	17	23	Average	0·95	23	0·18
8		,,	55	16	22	,,	0·73	29	0·14
9		Deep notch	60	16	26	,,	1·00	15	0·18
10		,,	60	15½	26	,,	1·10	20	0·15
11	11.vii.38	Plain girdle	55	16	22	,,	0·80	27	0·14
12		,,	52	16	19	,,	0·85	33	0·12
13		,,	81	15	46	Vigorous	1·05	14	0·27
14		,,	65	16	31	,,	1·30	16	0·27
15		,,	54	14½	19	Weak	0·75	25	0·14
16		,,	50	15	17	,,	1·50	28	0·07
17		Shallow notch	51	15½	18	Average	0·88	25	0·14
18		,,	62	15½	27	,,	1·23	21	0·22
19		Deep notch	67	15½	32	,,	1·13	16	0·25
20		,,	63	14	26	,,	1·10	14	0·33
A		Control	67	..	..	,,	1·25	13	0·27
B		,,	65	..	..	,,	1·08	16	0·20

* Based on a taper of 4 in. of girth per 6 ft. of length, and deducting 10 per cent. for volume of bark.

† Based on size of crown.

‡ Average figures from four increment borings taken at approximately 4 ft. and 16 ft. levels.

Springwood vessel formation had been completed by 30 May 1938, when the first ten trees were girdled. Examination of the November borings from these trees showed that very little summerwood formation had occurred; the amount was estimated to average about 10 per cent. of that expected on the basis of the controls, which showed 1938 summerwood to be about 75 per cent. of the width of that of 1937. On the other hand, the second set of trees, when treated on 11 July, already showed a little summerwood growth, estimated as

above at 25 per cent., which increased after girdling so that at the November examination an average of 67 per cent. of that expected had been formed.

(ii) *Effect of girdling on susceptibility of trees before felling to fungus and insect attack.* It was evident from examination of borings that a brown-staining fungus was present in the outer sapwood in the immediate neighbourhood of the barked area on the plain girdled and shallowly notched trees. This staining was of no economic importance. The sapwood of the trees which had been deeply notched, however, was severely decayed for a short distance above and below the girdle, and this was an evident disadvantage of the method.

No insect attack was seen in the bark or wood of any of the trees, nor was defoliation by *Tortrix viridana* L. evident during the course of the experiment.

(iii) *Effect on starch content.* The starch content was estimated according to the method previously described (3), the grade (0–6) of each $\frac{1}{10}$ inch of sapwood being recorded and a single average figure or 'starch index' calculated for each sample. It must here be reiterated that no precise mathematical significance can be attributed to these average figures, since the various grades have an arbitrary basis and bear no regular mathematical relationship to one another. To gain some information upon the reliability of an average calculated from four borings only, a special series of borings was taken in January from girdled tree 10 and control tree A. Six borings were taken at equal intervals round the tree at breast height and another six from just below the girdle or, in the case of the control, at 16 feet above ground. Three more were removed from the north and south sides of both trees between the upper and lower series already mentioned. The mean starch index was 4·42, and the corresponding mean starch index calculated from the usual four (January) borings was 4·50. Sampling with four borings may therefore be considered to yield an average which is close to the true mean starch index. This conclusion is supported by a similar examination of the borings from tree 10. It was considered possible that the boring operation might have some effect on the starch content of immediately adjacent tissues, and for this reason the borings were taken a few inches to left or right of previous ones. Nevertheless, occasional samples had abnormal starch contents compared with those of previous borings. The general consistency of the observations on successive samples, however, indicates that the boring operation has only a very limited sphere of influence.

The starch indexes of all samples, together with the corresponding percentage loss in starch content in November, January, and March, are shown in Tables IIA and B.

The group of trees 1–10, girdled in May, had lost more starch by November than trees 11–20, which were not treated until July, yet by January there was practically no difference between the starch losses in the two groups. For oak, therefore, so long as the trees are treated by July and allowed to stand at least six months, the exact date of girdling would appear to be relatively unimportant. There was no further loss in the starch content of the trees during February and March, the average loss by this time amounting to some 70 per cent. of the starch originally present.

TABLE II A. *Starch indexes and percentage loss of starch for trees 1–10 and controls*

Tree no.	Position. Butt (B) or top (T).	Position. North (N) or south (S).	Starch index (S.I.) and starch loss per cent. (L%). May 1938. S.I.	July. S.I.	November. S.I.	November. L%	January 1939. S.I.	January 1939. L%	March. S.I.	March. L%
1	B	N	4·00		0·11	97·2	0·00	100·0	0·00	100·0
		S	4·11		0·90	78·2	0·00	100·0	0·00	100·0
	T	N	4·25		3·13	26·4	0·13	96·9	2·88	32·2
		S	4·33		2·30	46·9	2·80	35·4	0·00	100·0
2	B	N	5·13		2·88	43·9	3·13	39·0	3·00	41·5
		S	5·57		3·75	32·7	1·13	79·7	3·00	46·2
	T	N	5·13		2·25	56·1	0·50	90·2	1·00	80·5
		S	5·00		2·71	45·8	0·13	97·4	1·63	67·4
3	B	N	5·40		3·25	39·8	1·81	66·5	3·40	37·0
		S	5·38		4·00	25·6	2·76	48·7	4·12	23·4
	T	N	4·93		3·50	29·1	4·08	17·5	3·53	28·4
		S	5·13		3·56	30·6	3·07	40·2	3·47	32·4
4	B	N	4·75		0·33	93·1	0·00	100·0	0·75	84·2
		S	4·90		0·82	83·3	0·00	100·0	2·00	59·2
	T	N	5·00		2·00	60·0	0·00	100·0	0·00	100·0
		S	5·13		1·78	65·3	0·56	89·1	0·13	97·5
5	B	N	5·88		3·85	34·5	2·80	52·4	3·91	33·5
		S	6·00		3·91	34·8	3·71	38·2	4·57	23·8
	T	N	5·67		4·14	27·0	3·00	47·1	3·38	40·4
		S	5·71		4·44	22·2	4·43	22·4	4·40	22·9
6	B	N	5·60		1·40	75·0	0·40	92·8	0·50	91·0
		S	4·75		3·33	29·9	0·89	81·3	1·63	65·7
	T	N	5·89		1·89	69·9	0·78	86·8	2·10	64·4
		S	5·50		2·89	47·5	0·09	98·3	1·50	72·7
7	B	N	5·86		1·00	82·8	0·33	94·4	0·22	96·2
		S	5·00		2·70	46·0	1·00	80·0	2·00	60·0
	T	N	5·11		3·56	30·4	2·78	45·6	2·73	46·6
		S	4·82		2·10	56·5	1·64	66·0	0·78	83·8
8	B	N	5·71		0·00	100·0	0·00	100·0	0·00	100·0
		S	4·75		0·18	96·2	0·00	100·0	0·00	100·0
	T	N	4·50		1·11	75·4	0·00	100·0	0·00	100·0
		S	5·17		0·14	97·3	0·00	100·0	0·00	100·0
9	B	N	6·00		1·70	71·7	1·10	81·7	1·33	77·8
		S	5·82		1·64	71·8	1·27	78·2	0·80	86·3
	T	N	5·40		0·00	100·0	0·27	95·0	0·44	91·8
		S	4·80		1·63	66·0	2·75	42·7	1·00	79·2
10	B	N	5·40		3·18	41·1	1·36	74·8	2·82	47·8
		S	5·58		2·00	64·1	2·42	56·6	2·85	48·9
	T	N	5·40		2·00	63·0	2·30	57·4	2·50	53·7
		S	5·08		2·58	49·2	1·33	73·8	2·27	55·2
					CONTROLS					
A	B	N	5·07	4·92	4·36	14·0	4·45	12·2	4·30	15·2
		S	4·38	4·33	4·42	−0·9	4·53	−3·4	5·36	−22·4
	T	N	4·17	4·27	4·42	−6·0	4·58	−9·8	4·15	0·0
		S	4·36	4·30	4·00	8·3	4·40	−0·9	4·58	−5·0
B	B	N		4·26	5·12	−20·2	4·50	−5·6	3·93	7·8
		S		4·13	4·85	−17·4	5·00	−21·1	4·33	−4·8
	T	N		3·85	5·00	−29·9	4·73	−22·9	4·00	−3·9
		S		3·39	4·50	−32·8	3·89	−14·8	3·88	−14·5

TABLE II B. *Starch indexes and percentage loss of starch for trees 11–20*

Tree no.	Position. Butt (B) or top (T).	Position. North (N) or south (S).	Starch index (S.I.) and starch loss per cent. (L %). July 1938.	November.		January 1939.		March.	
			S.I.	S.I.	L %	S.I.	L %	S.I.	L %
11	B	N	4·00	3·00	25·0	1·13	71·8	2·13	46·8
		S	4·00	1·78	55·5	0·38	90·5	0·00	100·0
	T	N	3·88	3·71	4·4	2·14	44·8	1·00	74·2
		S	4·29	2·13	50·3	0·00	100·0	0·30	93·0
12	B	N	4·80	3·11	35·2	0·25	94·8	0·13	97·4
		S	4·63	1·20	74·2	0·75	83·8	1·25	73·0
	T	N	4·63	2·38	48·6	2·44	47·3	2·50	46·1
		S	4·13	2·20	46·8	3·22	22·0	2·71	34·4
13	B	N	5·09	1·73	66·0	0·80	84·3	0·80	84·2
		S	5·25	3·27	37·7	1·00	81·0	1·25	76·2
	T	N	5·44	2·78	48·8	0·00	100·0	1·00	81·6
		S	4·90	3·10	36·8	0·22	95·5	0·20	96·0
14	B	N	5·50	3·00	45·5	1·46	73·5	1·71	68·9
		S	5·72	3·58	37·5	1·38	76·0	2·50	56·3
	T	N	5·07	2·93	42·3	3·31	34·7	1·17	76·9
		S	5·27	3·27	38·0	1·25	76·3	0·73	86·2
15	B	N	4·89	2·00	59·1	0·44	91·0	1·50	69·4
		S	5·43	2·00	63·2	0·43	92·0	1·14	79·0
	T	N	3·86	1·50	61·2	0·63	83·7	0·00	100·0
		S	4·57	1·71	62·6	0·14	97·0	0·00	100·0
16	B	N	4·40	2·23	49·4	1·47	66·6	1·07	75·7
		S	4·38	2·56	41·5	0·53	87·9	1·08	75·3
	T	N	3·80	2·36	37·9	0·77	79·7	0·64	83·2
		S	3·79	2·50	34·1	0·94	75·2	0·50	86·8
17	B	N	5·22	3·00	42·6	1·43	72·6	0·44	91·6
		S	5·00	1·78	64·4	0·78	84·4	0·70	86·0
	T	N	4·75	3·86	18·7	2·25	52·7	2·50	47·4
		S	4·56	3·50	23·3	1·75	61·7	1·67	63·4
18	B	N	5·69	3·92	31·1	2·67	53·0	2·18	61·7
		S	5·64	4·38	22·4	3·33	40·9	2·86	49·3
	T	N	5·50	3·22	41·5	2·64	52·0	3·50	36·4
		S	4·69	3·23	31·2	1·92	59·0	1·93	58·9
19	B	N	5·33	1·50	71·9	1·18	77·8	0·83	84·4
		S	5·36	3·00	44·0	1·42	73·5	1·69	68·5
	T	N	5·18	2·50	51·7	0·25	95·2	0·50	90·4
		S	5·55	0·86	84·6	1·43	74·3	2·71	51·2
20	B	N	5·54	2·91	47·5	1·75	68·4	1·69	69·5
		S	5·50	3·93	28·5	2·85	48·2	2·25	59·1
	T	N	5·73	3·64	36·5	2·50	56·4	2·50	56·4
		S	5·50	3·40	20·0	3·75	31·8	3·70	32·7

A marked drop in starch content of the experimental trees during the early part of the winter, reported previously (2), was again observed; this decrease, which is permanent and not merely a temporary change in the starch-sugar ratio, is not shown by the controls and is evidently, therefore, a result of the

treatment. It may be that the decrease is due to a continuation of the process of depletion by respiration and that in untreated trees a mechanism exists whereby such respiration is largely inhibited during the winter months. Wilson (4) has shown that the respiratory rate of oak sapwood during depletion at 41° F. is reduced only to one-half of that at 66·2° F. The mean monthly temperatures in the New Forest district were calculated from the weather reports of the Meteorological Office by averaging the means for the stations at Southampton and Porton, and are set out below.

May 1938	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*
51·2° F.	58·8	59·6	62·3	57·6	51·4	49·6

Dec.	*Jan. 1939*	*Feb.*	*Mar.*	*Apr.*	*May*
39·8	41·5	42·9	43·2	48·5	53·3

On the basis of these mean monthly temperatures, therefore, there is no reason why respiration, and hence starch depletion, should not have continued throughout the winter, but no significant change in the amount of starch was recorded after January, as was shown by observations made in March and September, 1939. This suggests the existence in the non-girdled tree of some positive means of ensuring dormancy in the living cells of the trunk wood during the winter, and further that, if this is brought about by downward passage from the crown region of an inhibitory substance, then this takes place in tissues outside the xylem, since considerable starch loss occurred in the experimental trees irrespective of the type of girdling treatment.

In the previous experiment (2) the trees after treatment were classified on the basis of their starch content into three groups, viz. non-susceptible, partially susceptible, or susceptible to attack by *Lyctus* Powder-post beetles, the number of trees in each group being 9, 8, and 3 respectively. A similar classification of the twenty girdled trees in the present experiment also resulted in a distribution of 9, 8, and 3 in the three groups as shown below.

Non-susceptible. *Tree no.*	*Partially susceptible.* *Tree no.*	*Susceptible.* *Tree no.*
4	1	3
6	2	5
8	7	18
9	10	
11	12	
13	14	
15	19	
16	20	
17		

Tables II A and B show that there has been considerable variation in the rate of starch depletion both within individual trees and between trees; these two types of variation are considered in detail in sections (iv) and (v).

(iv) *Variation in starch loss within the tree.* Before any idea can be gained of the causes of variation of starch content within individual treated trees it is clearly necessary to know something of the variation occurring normally. Some information on this point can be obtained by examining the starch indexes of borings taken from the girdled trees just before treatment in May and July (see Tables II A and B). A very rough numerical estimate of the normal variation in starch content within the tree was obtained by noting the range in starch index within the samples taken from each tree. The average of the values so obtained gave an average range of starch index of 0·69 for the twenty trees before treatment. The corresponding figure for the same trees after treatment was 1·49, 1·63, and 1·60 at the November, January, and March examinations respectively, showing clearly that whilst a certain amount of variation in the distribution of starch throughout a tree is normal, after girdling the variation is greatly increased, in spite of the marked lowering of the starch content.

The variation observed within trees both before and after treatment was found to bear no general relation to the position of samples in the tree, whether near the top of the trunk or the butt, or on north or south sides. From the detailed observations made on tree 10 and control tree A, it seems unlikely that more borings than four would have revealed any definite relations. Furthermore, the starch content of the samples appeared to depend in no way on their proximity to epicormic branches, nor on the relative amount of summerwood produced.

The radial distribution of starch in the sapwood was initially fairly uniform, although some borings showed rather less in the outermost rings. By March most of the starch had disappeared from the outer portions but an appreciable quantity still remained in the inner sapwood of the majority of trees. In Table III the radial distribution of starch at the time of girdling and in March is shown by the values obtained from averaging for the twenty trees the starch grade of each $\frac{1}{10}$ inch of sapwood from the bark inwards. The average starch loss per cent. for each $\frac{1}{10}$ inch is also given. The figures show that the amount of starch depletion decreases radially across the sapwood from the bark inwards in a fairly regular manner.

(v) *Variation in starch loss between trees.* At the time of girdling the mean starch indexes of the individual trees varied from 4·04 to 5·82, but by the end of the treatment (March 1939) the difference was more marked, the starch indexes ranging from nil to 4·07; the corresponding starch losses varied from 29·6 per cent. in tree 5 to 100 per cent. in tree 8.

The necessarily arbitrary values of the starch grades employed and the limited number of trees which it was possible, for practical reasons, to include in the experiment render any detailed statistical analysis of the observations unjustifiable. General examination of the data, although failing to establish any well-defined correlations, did, however, indicate certain interesting relationships. The variables dealt with included crown vigour, crown ratio, epicormic branch development, callus production, girth, general growth rate

of sapwood and growth rate during the three years 1935–7, width of sapwood, initial starch content, and type of girdling treatment.

TABLE III. *Radial distribution of starch in sapwood before and after girdling*

Distance from bark (inches).	*0·1*	*0·2*	*0·3*	*0·4*	*0·5*	*0·6*	*0·7*	*0·8*
Average starch grade:								
At start . . .	4·17	4·80	5·07	3·95	5·18	5·24	5·24	5·18
March 1939 . .	1·14	1·01	0·91	1·13	1·21	1·34	1·69	1·98
Starch loss per cent. .	73	79	82	71	77	74	68	62

Distance from bark (inches).	*0·9*	*1·0*	*1·1*	*1·2*	*1·3*	*1·4*	*1·5*	*1·6*
Average starch grade:								
At start . . .	5·45	5·44	5·30	4·89	4·22	5·23	5·55	5·66
March 1939 . .	2·32	2·80	3·50	4·36	4·33	5·00	6·00	6·00
Starch loss per cent. .	57	49	34	11	−3	4	−8	−6

It may be well at this point to consider briefly the general physiological factors which might account for differences between trees in respect of their starch losses. The figures in Table III, showing a radially diminishing starch loss within the tree, point to decreasing metabolic activity towards the inner sapwood. This may be related to an increasing difficulty in obtaining oxygen and disposing of carbon dioxide or other waste products and, in this connexion, the extent of depletion in the deeply notched trees indicates that the transpiration stream does not play an important part in this process. Apart from this variation within the tree, some trees exhibit a generally higher level of metabolic activity either inherent or induced by external conditions. This is reflected in such variable features as width of sapwood, width of the annual growth rings, and size of crown. The varying tendency of trees under comparable conditions to show irregular growth and to produce epicormic branches is another sign of differences in character of their vital processes. The production of hormones by the growing shoot and its role in the mobilization of reserve food materials suggest that the number and disposition of the branches and adventitious shoots is yet another factor to be considered. There is some evidence that epicormic branches below the girdle can affect winter starch depletion. The low winter loss in those girdled trees having numerous epicormics and the high loss in trees relatively free of them suggest that they exert a partial inhibitory effect below the girdle similar to that for which the crown may be responsible in non-girdled trees. Consequently the removal of epicormics from treated trees before the close of the growing season might help to ensure maximum winter depletion.

In view of the complex relations existing between these various physiological factors it will be realized that straightforward relationships between starch loss and the observed variables can hardly be anticipated. The present observa-

tions indicate that a narrow sapwood favours depletion, although this was not shown by the data obtained in the 1937 experiment (2). The reason for this discrepancy may be that opposing factors are concerned: a narrow sapwood contains a smaller initial amount of starch and presents less difficulty for gaseous exchange, but is often associated with a less vigorous or definitely unhealthy condition of the tree. A high rate of recent diameter growth also appears to favour depletion slightly. Of particular interest to the forester is the observation that trees with a relatively short but well-developed crown and clean bole tend to deplete more readily than those having a long but straggling crown and a tendency to develop numerous adventitious shoots.

PRACTICAL APPLICATION OF GIRDLING.

From the three experiments which have now been carried out, it is possible to draw some conclusions as to the value of this treatment for reducing the starch content of the sapwood of standing trees with a view to preventing subsequent infestation by *Lyctus* Powder-post beetles. Attention is drawn to the fact that the experiments have so far been confined to English oak (*Quercus robur* L.), and it is not known whether the results are applicable to other timbers.

Where felling can be planned 1–2 years ahead, girdling at the top of the bole offers a means of rendering about 85 per cent. of the trees relatively low in starch content and 40 per cent. immune against *Lyctus* attack, but owing to the great variability which may be encountered it is not possible to guarantee the results of the treatment. However, it must be pointed out that in two experiments carried out upon groups of twenty trees in different years and in widely separated districts the same proportionate success was attained.

The cost of girdling twenty trees in Godshill Enclosure was the equivalent of only 0·45 pence per cubic foot of timber below the girdles; this amount could be reduced if a greater number of trees were treated on account of the extra skill gained by the men. The total volume of sapwood treated, and consequently rendered in great part immune from risk of destruction by *Lyctus*, has been calculated as a little over 100 cubic feet, on which basis the cost of treatment amounts to 2·25 pence per cubic foot.

Girdling should be carried out in early summer, before the end of July: the trees are ready for felling in the following January, and there seems to be no advantage in leaving them standing any later than this. The type of girdle is unimportant in relation to starch depletion so long as the bark is cleanly removed from a ring 6–8 inches wide. The shallowly notched girdle is recommended as the safest type; deep notching is to be avoided on account of the greater tendency to fungal stain and decay. Creosoting the girdles does not entirely prevent fungal staining, but even without creosote the development of this defect is so small as to be of no practical importance.

It must be borne in mind that the starch is reduced in quantity only in that part of the trunk below the girdle and the treatment should, therefore, be carried out as high up the tree as possible. Slightly better starch depletion

might also be secured if epicormic branches were trimmed off before leaf-fall and particularly if trees could be girdled during the summer following a year of good seed production. Finally, it must be pointed out that depletion of starch does not stop when an ungirdled tree is felled, but continues if the log is kept in the round with the bark intact (4). Provided this applies also to girdled trees, a combination of girdling with subsequent log storage for a few months may well result in a reduction in starch content to a level at which the sapwood is no longer susceptible to damage by *Lyctus* Powder-post beetles, but there is no experimental evidence at present to substantiate this suggestion.

To summarize, therefore: unless further depletion can perhaps be achieved by storing the logs for a few months before conversion, starch depletion by girdling cannot be considered sufficiently reliable for general commercial use, because there may be a small percentage of trees in which the starch is depleted more slowly than in the majority. On the other hand, the treatment could probably be applied successfully in woods where trees having a long clean bole and strong compact crown could be selected as particularly suitable.

ACKNOWLEDGEMENTS.

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SUMMARY.

In view of variable depletion previously obtained, twenty oaks (*Quercus robur* L.) were girdled 16 feet above ground, ten in May and ten in July 1938, to study the variation more closely. Treatment cost 0·45 pence per cubic foot of timber below girdle. Considerable variation was again recorded within trees and between trees. Depletion continued until January 1939, although no winter loss occurred in controls, suggesting that dormancy is normally caused by respiration-inhibiting substances from the crown rather than low temperature. The results were considered in relation to date and type of treatment, crown vigour, crown ratio, epicormic growth, callus production, girth, general and recent growth rates and width of sapwood, summerwood development after girdling, position of sample in tree, and initial starch content. Narrow sapwood, high recent growth rate, a vigorous but compact crown, and long clean bole free from epicormic shoots appear to favour depletion. Final classification agreed with a previous experiment with twenty trees, three still having sufficient starch for *Lyctus* Powder-post beetle attack, nine being non-susceptible and eight partially susceptible. The method is considered insufficiently reliable for general commercial production of *Lyctus*-immune oak sapwood unless treatment is confined to selected trees.

LITERATURE REFERENCES

(1) Parkin, E. A.: 'The Depletion of Starch from Timber in Relation to Attack by *Lyctus* Beetles. II. A preliminary experiment upon the effect of girdling standing oak trees.' *Forestry*, xii (1), 30–7, 1938.

(2) —— 'The Depletion of Starch from Timber in Relation to Attack by *Lyctus* Beetles. III. A second experiment upon the girdling of standing oak trees.' Ibid. xii (2), 117–24, 1938.

(3) Phillips, E. W. J.: 'The Depletion of Starch from Timber in Relation to Attack by *Lyctus* Beetles. I. Starch, with special reference to its occurrence in timber.' Ibid. xii (1), 15–29, 1938.

(4) Wilson, S. E.: 'Changes in the Cell Contents of Wood and their Relationships to the Respiration of Wood and its Resistance to *Lyctus* attack and to Fungal Invasion.' *Ann. appl. Biol.* xx (4), 661–90, 1933.

THE EFFECT OF SAP-STAIN ON THE PROPERTIES OF TIMBER

III. EFFECT OF SAP-STAIN ON THE MODULUS OF ELASTICITY OF SCOTS PINE SAPWOOD

BY W. P. K. FINDLAY AND C. B. PETTIFOR

(Forest Products Research Laboratory)

IN a previous article[1] on the effect of sap-stain on the strength properties of Scots pine, results of tests showing the effect of the stain on the modulus of elasticity of the timber were included. These results were, however, somewhat contradictory and inconclusive, and the third series of tests on this property, to which reference was then made, has now been completed.

Since it is possible to evaluate the modulus of elasticity without destruction of the test piece, the tests in this third series were carried out on the same specimens before and after staining, thus eliminating the unavoidable differences between the stained specimen and its control. The modulus of elasticity was determined from compressive tests parallel to the grain, using for the purpose test pieces 6 inches long and 1½ inches square.

After determination of the initial modulus for each test piece, the specimens were sprayed with an aqueous suspension of spores of *Ophiostoma* (*Ceratostomella*) *coerulea* and stacked in a small kiln kept at 27° C. and 95–100 per cent. relative humidity for a period of about two months. A vigorous superficial growth of the staining fungus and of various moulds soon developed. By the end of the period the stain was very heavy on the surface, and from a few samples examined it appeared to have penetrated well into the interior, but it was subsequently found after test that the proportion of specimens with heavy internal staining was small. After removal from the kiln the modulus of elasticity was redetermined for each test piece, which was subsequently crosscut for estimation of the degree of staining.

Owing to the difficulty of accurate estimation of the amount of stain, the test pieces were divided for comparative purposes into two broad groups only: those with very slight or no staining and those with moderate to heavy staining. The table on p. 147 gives the results classified on this basis.

These results were examined statistically to determine whether the decreases obtained after staining were significant, that is, whether they were greater than might reasonably have been expected from the chances of sampling and experimental error only. As shown in the table, the very small decrease for the lightly stained material was not statistically significant, but the some-

[1] Findlay and Pettifor. 'The Effect of Sap-stain on the Properties of Timber. 1. Effect of Sap-stain on the Strength of Scots Pine Sapwood.' *Forestry*, 1937, xi (1), 40–52.

Modulus of elasticity of Scots Pine Sapwood before and after staining

Degree of staining.	*Number of results.*	*Modulus of elasticity—1,000 lb. per sq. inch.*				
		Before staining.	*After staining.*	*Decrease.*		*Significance of decrease.*
				Actual.	*Per cent.*	
None to slight . .	58	1,430	1,420	10	0·7	Not significant
Moderate to heavy .	25	1,450	1,410	40	2·8	Significant

what greater decrease for the more heavily stained timber was found to be significant. It was, therefore, concluded that the slight staining caused no decrease in the modulus of elasticity of the timber, but that this property was adversely affected by a higher degree of staining. From a practical point of view, however, the decrease, even for the more heavily stained timber, though real, is not large enough to be of importance and may safely be neglected.

REPORT ON AN EXCURSION TO ALLERSTON FOREST 1939

BY R. G. SANZEN-BAKER

THE Society paid a two days' visit in July to Allerston Forest in Yorkshire, the object of the excursion being to study the problem of 'Afforestation in the South-eastern Section of the Yorkshire Moors'. The Forestry Commissioners have acquired in this neighbourhood approximately 18,000 acres, of which they have already planted about 9,500 acres. Allerston Forest, the largest of the units in this district, is made up of four more or less detached blocks lying a few miles to the west of Scarborough. The total area of the forest is over 11,000 acres, of which about 7,500 have already been planted.

The mass of lowland hills which form this portion of the Yorkshire Moors is intersected by a number of moderately steep-sided valleys which are known as 'dales'. The area thus provides two distinct types of land for afforestation, the more difficult being the exposed upland heaths which, in the main, have not carried a forest vegetation for a very considerable time, if ever. The 'dales', which at one time were almost certainly heavily wooded, generally are sheltered and possess much more favourable soil conditions for tree growth.

In order to enable the reader to obtain a clearer insight into the problems that confront the forester in this region it will be necessary to refer briefly to the geological and other features of the area. (For a more detailed description of soils reference should be made to G. V. Jacks, *Forestry*, vi. 27.)

The two blocks of Allerston Forest visited, namely Dalby on the first day and Wykeham on the second, occur mainly on the Lower and Middle Calcareous Grits of the Middle Oolite. The Greystone ('Passage Beds'), which gives a free yellow sandy soil, is exposed in places, and Coralline Oolite limestone occurs locally. Alluvium is to be found in the valleys, also a certain amount of Oxford Clay. There is no glacial drift on the moors. The Middle and Lower Calcareous Grits are both orange-yellow in colour and are described as siliceous sandstones; it would appear that all calcareous matter has been washed out as the rocks now give a strong acid reaction.

The moors consist of extensive gently sloping tracts which are almost flat over considerable areas. The elevation is approximately 500 to 800 feet above sea-level. The soil type of these moors, except on the 'Passage Beds', is that of the 'podsol', while that of the dales is generally a 'brown earth'. Most of the moorland areas are covered with heather peat, usually structureless and well decomposed. This peat varies in depth but is rarely more than 7 inches, the variation being due partly to the one-time frequent practice of heather burning which largely destroys the peat. Below this there occurs typically a layer of from 4 to 9 inches of leached light grey compacted sandy soil with pebbles,

occasionally and, in places, large stones. This is underlain generally with a very thin peaty layer formed from decomposing roots. Beneath it is a thin hard brown pan which is sometimes unbroken and at a constant level over appreciable areas. Elsewhere the pan may be wavy and discontinuous; this condition may represent a stage of development towards the level pan. The pan may occur at a depth of from 6 to 9 inches, and below it is a layer, 4 to 10 inches in thickness, of red-brown compact soil showing a tendency to laminated structure; this passes into the densely compacted yellow or yellow-orange subsoil.

In spite of the relatively low rainfall, which averages about 33 inches per annum, and the apparently sandy soil, drainage of the more or less level stretches of moor presents some difficulty and the ground lies very wet throughout the winter. Mr. G. V. Jacks came to the conclusion that the soil above the pan is quite permeable to water, that the B horizon, that is, the pan and the red-brown soil immediately below, is slightly permeable especially in a lateral direction, and that the yellow-orange subsoil, or C horizon, is very impermeable.

The vegetation of the moors is dominantly *Calluna vulgaris*; this is often the sole species. The ling appears to derive its mineral nutriments mainly from the thin peat layer, judging by root activity. It is most luxuriant on peat at least 6 inches deep, and here very few other species occur. However, where the peat is of considerable thickness *Eriophorum vaginatum* may be present with the *Calluna*, and may be locally dominant. Where the ling is less vigorous the following plant associates may occur with others: *Erica cinerea*, *Empetrum nigrum*, *Vaccinium myrtillus*, *Cladonia* spp., and on the wetter sites *Erica tetralix*, *Molinia caerulea*, *Nardus stricta*, *Juncus squarrosus*, and *Cladonia* may be found with the *Calluna*.

The afforestation of the dales, compared with that of the ground described above, is a relatively easy matter. As has been stated, the soils are normally 'brown earths' which are characterized by the dark brown to black colour of the upper layers of the mineral soil merging without any sudden change into the colour of the subsoil. There is normally no drainage problem, but frosts are often troublesome.

The chief feature of the vegetation is that bracken replaces ling on the Calcareous Grits and Passage Beds on the dale slopes except those with a northern aspect. Here ling is usually dominant, with bracken occurring in patches and becoming dominant locally. Elsewhere on these soils bracken is the principal species and, in places, grows very strongly; ling and a wide range of other plants, of course, are interspersed. It is generally accepted that the dominance of the bracken is determined by better soil conditions: freer drainage, better aeration, and probably less acidity. On certain sites *Rubus fruticosus* occurs with associates, and in wetter places *Deschampsia caespitosa* is found. Where the limestone appears at the surface the flora consists almost entirely of grasses, severe grazing of which has occasionally resulted in exposure of the rock even on gentle slopes. After enclosure, such exposures tend to be recolonized by grasses and scattered hawthorns.

The Forestry Commission first started planting at Allerston Forest in forest year 1921; this was in the Dalby area. Most of the main dales and the relatively narrow 'riggs' between them were dealt with before attempting to plant the true upland heath ground for which a special ploughing technique has been developed. It was to inspect the results of this work that the Society spent the first day of the excursion in this area, under the able guidance of Mr. O. J. Sangar, the Assistant Commissioner for England and Wales, and of Mr. R. E. Fossey, the District Officer, to whom the writer is indebted for information on the forest generally and on individual plantations.

As a fitting introduction to Allerston Forest, the Society was conducted to a high place from which an excellent view of the forest (Dalby Warren area) was obtained. The older plantations, 16 to 19 years old, of Corsican pine, Scots pine, Japanese larch, European larch, Norway spruce, and Sitka spruce provided material for some interesting discussions on treatment. The majority of these plantations had been successfully established; European larch, however, had been particularly backward but was now improving rapidly. Frosts had been very troublesome, especially with this species. It is very striking, particularly on the 'riggs' and north-facing slopes, that on bracken ground all species had met with success while close by on the *Calluna* there had been practically complete failure except with Scots pine and Japanese larch. On this type of ground, beating up had been carried out with Scots pine, Japanese larch still being a somewhat doubtful proposition.

A point of considerable interest was the case of where a forest fire in June 1936 had stopped along the edge of a Japanese larch plantation in canopy after destroying adjoining European larch. Several other instances of this had since been recorded, and it was now generally accepted that Japanese larch was very valuable from this standpoint.

During the afternoon, some of the upland heath plantations at Givendale Head were visited. Here the Society made its first acquaintance with the main problem of the afforestation of these moors. The Commission's work in this respect began in 1923, when an area on South Moor was shallow ploughed and planted (P. 24) with a variety of species. Results were very poor, Scots pine and Japanese larch again being the best species although both are variable, especially the larch. Both Norway and Sitka spruce are generally very feeble and far from being a success. Corsican pine and European larch are very irregular; the majority of plants have failed, but the survivors are not unpromising. Douglas fir is very poor indeed and not worth considering. *Pinus ponderosa* has failed heavily in certain plots, and the survivors, although healthy in appearance, are making slow growth. In 1931 part of the area was reploughed, this time deeply, and replanted with a wide range of species. Results have been very much better. The pines are undoubtedly the best; *Pinus contorta* is the most uniform, and Mountain pine is making slow but steady progress. Both spruces are variable, with many trees making quite fair growth and others not growing at all. Sitka spruce is undoubtedly the better of the two. The larches are not at all promising and the Douglas fir appears to be hopeless.

Work on a larger scale was undertaken in 1926, when a long strip of *Calluna* ground, 10 chains in width, in the middle of the moor at Allerston was planted with Scots pine and Norway spruce in equal mixture without ploughing. The spruce developed so poorly that 10 years later they were ploughed out and replaced by Scots pine. This early work was followed by the planting of various mixtures in which Scots pine predominated, the other species being a spruce, generally Norway, or a larch and a few beech, most of which died very soon. Experience showed that neither Norway spruce nor European larch were suitable trees. Sitka spruce began to be more popular, but results with this species and with Japanese larch are very variable. Scots pine, while consistently better than the other species, was very slow in becoming established. Ordinary shallow ploughing was then tried, but this gave little better result than natural surface planting.

In forest year 1930 revolutionary strides were made by the introduction of heavy tractor ploughing. On this deeper ploughing, pines have been successful wherever tried, including *Pinus contorta* on the pockets of deeper peat. Sitka spruce has proved itself to be a useful species on the better sites occurring locally, particularly where there is more moisture. Japanese larch, and even European, are possibilities on selected sites. As a result of this experience, the great value of the Caterpillar tractor and plough equipment is unquestionable. A more recent development has been the use of a subsoiling attachment. This is considered to be a great improvement and to have a marked ameliorative effect on the drainage. Deep single-furrow ploughing with subsoiling is now the standard method of ground preparation.

The Society also inspected some of the older dale plantations in the neighbourhood of Low Dalby. Here, P. 24 Scots pine plantations on both Oolite Limestone and Calcareous Grit excited considerable attention in view of the fact that on the former strata the pine is showing signs of dying in groups although the plantation has been in canopy for some time, while on the latter formation the pine is mainly quite healthy. Corsican pine in mixture with the Scots on limestone soil nearby appeared to be healthy, although some of the Scots were affected. Since the Society's visit, Mr. T. R. Peace of the Imperial Forestry Institute has made a preliminary investigation of the disease which he found to be more or less confined to the limestone soil which gave a pH value of 7·0, while that of the Calcareous Grit soil was 5·0. The general symptoms are a yellowing of the needles, many of which are shed, and a stunting of the new shoots. Actual death of the tree appears to follow this condition fairly soon. Dr. I. Levisohn of Bedford College has reported on the mycorrhizal condition of the roots of trees from both areas. Briefly, without going into details of the report, the roots growing on the limestone soil show an abnormal condition with haustorial type of fungal infection which is regarded as pseudomycorrhizal and which is associated with defective growth and often with bad colour of the needles. Dr. Levisohn suggests that the fungus concerned is a suitable mycorrhiza former, but that some inhibiting condition or conditions in the soil are unfavourable to normal mycorrhizal formation and bring about the

pseudomycorrhizal type. Scots pine roots from the acid Calcareous Grit soil were found to be apparently healthy and showed a normal mycorrhizal condition. Pending further and more detailed investigation, the diseased condition appears to be associated, somehow or another, with a derangement of the finer root system as a result of soil conditions.

During the second day of the excursion the Society confined its attention largely to a study of the experiments carried out on Wykeham Low Moor by the Research Branch. The experimental block lies at an elevation of approximately 600–700 feet above sea-level and is fully exposed. The underlying rock is the Lower Calcareous Grit, and the soil is a typical podsol such as described above. The vegetation is dominantly *Calluna* with patches of *Erica cinerea*, and where the ground is wetter other species such as *Molinia* occur. In this short account it will be quite impossible to enter much into the details of the work, but a brief résumé of the more outstanding features will be attempted.

Experimental work on this area was commenced in 1928, and up to the time of the Society's visit some forty-six experiments had been laid down. Most of the problems which arise on a site of this kind have been covered, and the experiments have gone a long way to solving some of these. The major project has been probably the question of soil preparation, and several of the larger experiments have been designed to study this. Trials of various species of trees have been an important feature of the research work, and for obvious reasons it has been found desirable to include such trials with those of soil preparation. Also, with this work it has been usual to incorporate trials of artificial manures, particularly basic slag, which has been effective in most cases in improving the growth of a considerable number of species.

Earlier experience in plantation work had shown that natural surface planting on this type of ground did not give satisfactory results or, at the best, delayed establishment. This appeared to be due to a number of factors such as the tight nature of the surface peat and the compacted soil coupled with bad soil aeration and the presence of the pan. Also, the soil was obviously of a very infertile character; exposure, too, undoubtedly played its part in inhibiting growth. The first experiments (Nos. 2 and 3, P. 28) provided for the planting of various species in patches in which the soil was loosened with the mattock; there was no manuring. The pines, as a result of this treatment, have not been totally unsuccessful; failures have been heavy, however, and growth very slow. The larches and Sitka spruce have all done very badly. In experiments 4 and 6, P. 28, attempts were made to break up the pan with explosive charges, but this treatment has produced little effect. Also, in experiment 6 three methods of ploughing were tried, namely, complete ploughing, three-furrow strips, and single-furrow ploughing. The soil was only disturbed to a depth of about 4 inches in each case, nevertheless with full and three-furrow ploughing an appreciable improvement in growth has resulted compared with the results of prepared patches and, more particularly, with those of single-furrow ploughing, direct notch planting, and preparation with explosive charges. A trial of slagging was made in the three-furrow ploughing and this has resulted in

improved growth to the extent of 25 to 50 per cent. of all species, namely, Scots pine, Corsican pine, Sitka spruce, and Japanese larch. An interesting development is the marked improvement in the present rate of growth and appearance of Sitka spruce in mixture with Scots pine as compared with that of spruce.

A large experiment with several species and manurial treatments was carried out, also on shallow three-furrow ploughing, in 1929, but in 1931 the treatment which was largely to solve the problem was introduced; this was deep ploughing. From this time onwards, the heavy caterpillar tractor-drawn plough, working to a depth of about 8 inches, was employed for practically all soil preparation work. The improvement in growth of all species resulting from this deeper soil cultivation, involving as it does the rupturing of the pan over a considerable part of the area, is quite striking. In subsequent experiments (in particular No. 11, p. 31 and P. 32) complete ploughing has been compared with double-furrow ploughing both with and without subsoiling. Growth of Japanese larch, European larch, *Pinus contorta*, and birch is much better on the complete ploughing than on the double-furrow ploughing, but in this experiment subsoiling has had little effect upon the growth.

The experiments have thus shown that there is a general response of all species, particularly the larches, Sitka spruce, and broad-leaved trees, to cultivation. Pines have given the most consistent results; they have shown a significant response to manuring with basic slag, but it is doubtful whether this is justified economically. Sitka spruce, while having responded to slagging, has fallen off in growth during recent years, except possibly where it has been planted in mixture with pine. This fall off in growth may have been due to climatic causes, but it is sufficient to discourage the planting of pure Sitka spruce. Without slag this species remains in check indefinitely on the poorer ground. It appears that the only possible way of raising Sitka spruce with any hope of success is to plant it on deeply ploughed ground in mixture with some other species, such as Scots pine, and to apply basic slag at the time of planting.

Japanese larch has given usually very poor results where not manured, but when planted on deeply ploughed ground with basic slag it gives quite promising results. In experiments 26, P. 33, and 33, P. 34, this species has already formed canopy. The same provisions apply to European larch, but it is not so good as the Japanese larch at this forest.

Other points of interest that have been the subject of experiment include the use of 1-year seedlings of Scots pine, Sitka spruce, and *Pinus contorta*, with surprisingly good results in so far as the pines are concerned (experiment 12, P. 31). Sowings of broom with the application of phosphatic manures have been successful and provide possible means of establishing Sitka spruce by interplanting the broom; early results of this work are promising. The use of organic composts, prepared by Dr. M. C. Rayner, in seed-beds on the moor has given remarkable results with sowings of various pines. This work is being followed up and seedlings so raised are being used for experimental planting. This appears to be a promising line of investigation. More recent work at

Allerston includes a large-scale provenance experiment with *Pinus contorta* (experiment 55, P. 38), but of course it is too soon to expect any appreciable differences in growth.

It remains but to mention a walk through some old plantations in Beedale on the estate of Lord Downe. These plantations were formed *circa* 1865 and include Douglas fir which has now reached a height of about 120 feet, also excellent Norway spruce and *Abies nordmanniana*. These provide some indication of the possibilities of coniferous plantations on the better sites in the dales.

THE FORESTRY SUB-SECTION OF THE BRITISH ASSOCIATION, DUNDEE, 1939

CAPTAIN GEORGE I. CAMPBELL, Jr. of Succoth was Chairman of the sub-section, and Mr. Thomas Thomson was again Secretary. The meeting was interrupted by the outbreak of war, but the following papers were presented:

Capt. G. I. Campbell: 'Forestry in Scotland'.

Discussion on the Larches.

Dr. S. E. Wilson: 'The Qualities and Uses of Larch Timbers.'
Dr. M. L. Anderson: 'The Silviculture of the Larches.'
Mr. J. A. B. Macdonald: 'Larches on Peat and Poor *Calluna* Types.'
Mr. J. M. Murray: 'The Hybrid Larch.'
Mr. Fraser Story: 'The Sudeten Larch.'
Mr. W. R. Day: 'The Diseases of the Larch.'

Dr. A. B. Stewart: 'The Maintenance and Improvement of Soil Fertility in Nurseries.'
Mr. J. A. B. Macdonald: 'Experiments on Season of Sowing, Weed Control, and some other Nursery Problems.'
Mr. R. Davey: 'Forestry for Game.'

SOCIETY'S AND OTHER NEWS

THE LATE THE RT. HON. SIR FRANCIS DYKE ACLAND, BART., P.C., M.P.

The death of Sir Francis Acland has robbed this Society of a former President whose interest in the advancement of British forestry was unrivalled and whose services to this cause will be remembered for many years to come. These services were the greater because Acland's interest was not so much in the finer technical points of silviculture as in the value of forestry to the nation as a whole and as an instrument for the betterment of rural conditions and the general rehabilitation of the country-side—matters in which Acland was keenly interested, and to which he devoted a great part of his energies. This wide outlook and his political experience are reflected in the report of the Forestry Sub-Committee of the Ministry of Reconstruction which was set up under his chairmanship towards the end of the last war; there is little doubt that the wide basis upon which this so-called 'Acland Report' was framed contributed not a little to its adoption by the government. The report and the consequent establishment of the Forestry Commission, upon which Acland served as a Commissioner until his death, marked a new phase in the history of British forestry and are a perpetual and worthy monument to him.

Acland's wide outlook and keen interest in all the many social problems bearing upon the well-being of the country-side did not mean any neglect of detail; he was too full of sound, practical common sense. This is clearly evidenced by the simple statements of fact and the general straightforward nature of the instructions given in the Forestry Commission bulletin on *Forestry Practice* for which he was responsible, and which typifies his penetrating ability to get down to essentials, and his habit of direct approach to a problem. The same outlook governed the management of Acland's estate at Killerton; there were here some fine and rare specimens of Magnolias and other interesting trees and shrubs, beautiful gardens, and well-cared-for woodlands. The latter were managed on severely practical lines, and with great efficiency. He was also a director of the local woodland owners' association, a co-operative body established under the advice of the Forestry Commission, to assist the economic management of woodland estates.

Idleness was unknown to Acland, nor would he suffer it in others. He was intolerant also of stupidity but had a never-failing kindness and humour. All who were in genuine need of help or advice could rely upon his willing and unsparing assistance, often given with a glint of humour, and always with a charm inseparable from this unusual and lovable character.

O. J. S.

THE LATE PROFESSOR ROBERT SCOTT TROUP, C.M.G., C.I.E., D.Sc., F.R.S.

It is with deep regret that we have to record the death of Professor Robert Scott Troup, which took place at Oxford on 1 October 1939.

Troup was born in 1874 and was educated in Aberdeen, at the Gymnasium, Grammar School, and University. About a year ago he visited his first headmaster, the late Dr. John Clarke, and on his return he described how he had the same feelings as he had

had over fifty years before when he first entered the same study. He proceeded before graduation to Coopers Hill where he received his forestry training. In an after-dinner speech some fifteen years ago in Oxford, the late Sir William Schlich dwelt on Troup's prowess at Coopers Hill as a player of rugby and the bagpipes. In the academic sphere, he was the most distinguished student of his year.

He joined the Indian Forest Service in 1897 and was posted to Burma, where he spent seven years which he often looked back to with pleasure. It was, however, during his tenure of posts at Dehra Dun that he laid the foundation of his future reputation. While silviculturist, he travelled widely in India and accumulated much data both from observation and investigation. His monumental work in three volumes, entitled *The Silviculture of Indian Trees*, published in 1921, was the fruit of this period. During the last war he was Assistant Inspector-General and Controller of Timber Supplies in India.

In 1920 he was selected to succeed his former teacher the late Sir William Schlich as Professor of Forestry at Oxford. On the formation of the Imperial Forestry Institute in 1924 he became its Director. His nineteen years at Oxford were busy and productive. The part he played both in training undergraduates, and men who returned to the Institute for refresher courses enabled him to exert great influence in forestry development within the Empire. He also attended all the Empire Forestry Conferences, and at the request of the Colonial Office visited Kenya and Tanganyika. He thus came into personal contact with most forest officers in the Empire. As a forestry educationalist, he believed in the value of a close study of forestry in those countries that had initiated and developed systematic forestry, namely, in France and central Europe. Even while in India he had studied and written about silvicultural systems in Europe, and in 1928 he published his book on that subject. No other book in any language had dealt so comprehensively with this subject and it is held in high esteem on the Continent as elsewhere. He also prepared a book on *Exotic Forest Trees in the British Empire* which was based on data presented by the different parts of the Empire to the Empire Forestry in Australia and which appeared in 1932. At the time of his death he had completed a book on *Colonial Forest Administration.*

Troup was a shy and diffident man, and he was not at his best in the lecture room. He much preferred to teach in the forest, and it was on tours with his students that he was most inspiring. As an investigator, he excelled in the patient and painstaking compiling of data. All who know his two principal books appreciate the tremendous amount of work that they involved. He was no superficial generalizer. Moreover, few, if any, men in the forestry world had such gifts of lucid and concise expression. It was indeed fortunate for forestry that his opportunities in India and Europe were a suitable field for his exceptional gifts. He believed and systematically taught that silvicultural considerations must be the basis of forestry development. Other considerations must be taken into account, but that should remain fundamental.

Troup's shy manner made it difficult for him to make friends readily, but those who were privileged with his friendship knew how deep and loyal it was. The forestry world has lost a great exponent, and some a warm friend.

Professor Troup joined this Society at its formation and was its first Vice-President.

H. M. S.

THE LATE JOHN MURDOCH MURRAY, B.Sc., F.R.S.E.

On Saturday, 30 September, Mr. John Murray, Assistant Commissioner of the Forestry Commission, Scotland, died suddenly at Perth. To all but his most intimate relatives his death came as a great surprise.

Murray's training in forestry work was as nearly perfect as one could plan. His father, the late Mr. A. Murray, was a forester who assisted many men besides his son to see matters of real forestry importance in their true perspective and to free themselves from much of the dead and formal teaching of what was euphemistically called 'scientific silviculture'. In the Royal Botanic Gardens of Edinburgh Mr. John Murray acquired an extensive knowledge of systematic botany from one of the best systematists and finest teachers of the time, but in addition he acquired that rare love and knowledge of plant life and that ability to recognize plants once seen or handled that do not always accompany systematic knowledge. This knowledge of plants was his great pride, and in his enthusiasm for love of fine distinctions of the plants which he knew best he excelled even his teacher. Murray's record as a student in the University of Edinburgh was brilliant. His very special subject of study was Scots Pine, and throughout his busy life he occupied the greatest part of his spare time at this work. He has left in a well-advanced stage of preparation a record of his work which his colleagues and friends hope may be published. Murray's knowledge of what had been written and what had been done in forestry subjects was so detailed and so extensive that it is difficult to imagine how he found time to acquire it. His excellent memory and his firmly grounded opinions made him a most awkward opponent in the discussions that must arise among men who are interested in the work. Very early in his career he recognized the importance in British forestry of work done by foresters in north European countries, and in their work he found much to help him in his own special study.

Much more important than his extensive knowledge was his ability and readiness to use and apply it and to allow his colleagues the advantage of it. Although he was naturally a shy and reserved man, he had a quiet confidence in himself which inspired a similar confidence in men who had to rely on him for guidance. The official position which he occupied is a good measure of his value in the Commission. Murray's greatest service to British forestry is the service of a great teacher who loved and understood the subject which he taught. If his methods were not ordinary methods they were not of less value on that account, and many of us are indebted to him for the ideas and ideals which he gave to us. This estimate of his work, I believe, would satisfy even a man with Murray's high standards. He enjoyed his work and his friends' memories of him are pleasant and inspiring.

At the time of his death, Mr. Murray was Vice-President of this Society. J. F.

REVIEWS

Manual of Indian Silviculture. Part I. *General Silviculture.* By H. G. Champion. Part II. *Silvicultural Systems.* By Sir Gerald Trevor. Oxford University Press, 1938. Price 30*s*.

Review by the Editor

TROUP'S *Silviculture of Indian Trees* was an important milestone in Indian forestry, because it gathered together all the then available information on the forest trees of India. The volume under review marks another important stage, because here is a general text-book on silviculture almost entirely based on Indian conditions, investigations, and experience. It is not only an index of the maturity of Indian forestry but is a pioneer volume on tropical silviculture.

In general layout the book follows customary lines. In Part I, Chapter 1 deals with the locality factors of the forest. All relevant aspects of climate and soil are dealt with succinctly but lucidly. This chapter is a masterpiece of well-balanced compression, and the reviewer does not know of a better summary of this subject. Chapter 2, on the growth and form of trees and crops, is based generally on Burgen's *Structure and Life of Forest Trees*, but the examples are almost wholly drawn from Indian sources. This deals with the growth and form of trees rather than crops, and this applies also to the next chapter on tree and crop physiology. It would have added to the value of the book if the structure and physiology of stands had been dealt with as a basis, for example, for tending dealt with in a later chapter. Chapter 4, on forest composition and distribution, deals briefly but interestingly with the natural development of forests and their reaction on the site. It is a measure of the balance which has been maintained throughout that Mr. Champion only devotes a dozen pages to the classification of forest types, and therein summarizes what is contained in almost 300 pages of his publication on this subject. The remaining chapters deal with the practice of silviculture. The chapter on natural regeneration approaches the subject from a practical rather than a theoretical angle. A more ecological approach might have been more interesting, but having regard to the purpose for which the book has been prepared, less useful. The chapter on artificial regeneration also has a practical flavour and will be of great interest to silviculturists everywhere. There is a short but authoritative account of *taungya* methods, and both costs and records in connexion with artificial regeneration are touched upon. There is then a short but valuable chapter on afforestation, which includes an interesting account of work in the irrigated plantations of the Punjab. The chapter on tending which completes Part I is the best summary we have in English on this subject. As a basis, the standard Indian tree classification system is used naturally, but the author states that it is not altogether satisfactory as one would expect. Even for pure stands of temperate species an additional canopy class has proved desirable. A wide range of thinning methods are dealt with briefly, from the primitive *stick* method used in the Punjab to Gehrhardt's *Schnellwucksbetrieb* and Craib and O'Connor's methods. All the important points are at least touched on: time of first thinning, thinning in mixed crops, factors affecting thinning practice, thinning in irregular crops, &c., as well as weeding, cleaning, pruning, &c.

Part II deals with silvicultural systems on orthodox lines. In classification and method

of approach, the author follows Troup, but only such systems as have been applied to India are dealt with. There is much of interest in this section, particularly the results obtained from different systems in different forest types.

The authors are to be congratulated on an important work. Foresters outside India should not be deterred from studying this manual by its title. Most of the book is of interest to silviculturists generally and, as already noted, certain sections constitute excellent summaries of existing knowledge of the subject in general. A feature of the book is the beauty of the illustrations, and the publishers and printers are also to be congratulated on the production of the manual.

Elementary Forest Mensuration. By M. R. K. Jerram, M.C. London: Thomas Murby & Co., 1939. Price 8*s.* 6*d.*

Review by W. M. McNeill

IN the family of forestry subjects forest mensuration has come of age, and, although it may not be one of the most favourite members of the family, it deserves separate and special recognition. The absence of concise and comprehensive text-books on the various subjects which enter into the study of forestry has long been a practical difficulty to teachers and learners alike. Mr. Jerram has performed a useful and desirable service in providing a book which deals with forest mensuration as a separate subject and which presents the subject in a form specially designed for the forestry student.

The author has had considerable experience in the teaching and presentation of forest mensuration, and this experience is evident in the book under review. The theory and practice of measuring individual trees and woods are clearly set forth with descriptions of the instruments most commonly used. Examples and diagrams are liberally supplied to help the learner. Separate chapters deal with volume tables, increment, and yield tables. In connexion with the latter much of the recent and thorough research work done by the British Forestry Commission in the compilation of yield tables for conifers in Great Britain has been incorporated. Although the book is modestly designated as 'Elementary', it provides all the information on the subject which a forest officer starting his career should know.

Mr. Bourne, who has had exceptional experience both as a forest officer and a teacher of this subject, contributes a final chapter on 'The Measurement of Forests' in which the somewhat indigestible statistical method is leavened by emphasis on ecological considerations.

The book contains 122 pages of somewhat close print, it is light in weight and can be carried in a fair-sized pocket.

Schlich's famous Volume III of his *Manual of Forestry* will be vividly remembered by many foresters whenever the subject of forest mensuration is mentioned. This historic work is still invaluable, but it is unfortunately out of print and Mr. Jerram has supplied us all with a very useful and modern book to take its place.

Marketing Timber and other Woodland Products. By Reginald Davey. London: The Estates Gazette, Ltd., 1939. Price 5*s.*

Review by W. M. McNeill

THIS little book is a printed copy of Mr. Davey's thesis for the degree of Master of Science in the University of London. The title is ambitious but the author confines himself to an examination of home-grown and particularly privately owned

estate forest products. The principal uses to which these products may be put are summarized and the ruling prices are stated.

The problem of disposing profitably of home-grown timber in competition with imported material is a difficult one and the solution cannot be quickly or magically found. Undoubtedly there is room for improvement in existing methods or lack of method of disposing of estate forest produce, but it might be suggested that the real solution of the problem lies in an improvement of the methods of production. Advanced and progressive silviculture in forestry, no less than improved methods in agriculture, are the surest way to compete successfully in the sale and marketing of produce.

As must necessarily occur in these days of change and upheaval, much of the data given regarding cost and sale prices is liable to variation, but Mr. Davey has collected together in handy form a lot of information which is useful and which up to the present it has been difficult to obtain readily.

Das Holz als Rohstoff. (Wood as a Raw Material.) By A. Trendelenburg. J. F. Lehmanns: Munich and Berlin, 1939. pp. 435 with 108 illustrations. Price 13·50 RM.

Review by L. Chalk

THE multifarious uses for wood in the modern world demand an increasingly exact knowledge of its nature and properties. Not only must the practical man concerned with utilization understand something of the scientific background, but it is equally important for the forester to understand how the structure and properties of a timber may be affected by the silvicultural technique that he may adopt for the growing of the tree. There is only too often an invisible barrier between what may be called technological research on wood and physiological research on the living tree. The highly commendable object of the book under review is to destroy this barrier and to provide fare both for the forester who is entrusted with the growing of the tree and for the practical man of the wood-using industries that change the living raw material into valuable products.

The book begins with an account of the forests and wood-using industries of Germany and of the statistics of production and consumption. This is followed by a section on the development and anatomy of wood, which includes interesting accounts of cell dimensions and their variation in different woods and in different parts of the same tree, and of the chemical constituents of wood. The author then, so to speak, changes to a lower magnification and considers the whole stem, using the growth ring as his basic unit in place of the cell. This section includes the anatomy and physiology of ring formation, stem form, branches, and a very interesting account of heartwood and sapwood.

The next main section deals with moisture in wood from several different angles and contains many interesting tables and figures. Another important section is that devoted to the specific gravity of wood. Specific gravity is taken as the most convenient index of the effect of various internal and external variables, and this section is really devoted to a discussion of the effect of such factors as position in the tree and in the ring, the quality of the stand, seed origin, rate of growth, and the efficiency of the crown. This section also is well illustrated by tables and figures, many of them from the author's published and unpublished researches. For example, there is a diagram in which the specific gravity of tropical woods from the Cameroons is compared with that of

European hardwoods, which shows how misleading is the common assumption that tropical woods are denser than those from temperate climates. The diagram shows that the modes of the two distribution curves are identical—at about 38 lb. per cu. ft.—but that the range of the tropical timbers, as perhaps might be expected from their greater number, is considerably greater in both directions, but particularly towards the greater densities. The variation of specific gravity within the tree, a subject on which the author has himself done valuable research, is treated in considerable detail, much use being made of diagrams of individual trees showing the general trends of variation in longitudinal section by means of isobars.

The final section is devoted to the value of wood as a raw material after it has been broken down by chemical means. This is a subject of increasing importance and one that has received greater attention in Germany perhaps than anywhere else.

The author has set himself the task of doing something that has not been done before, and in doing this he has succeeded in producing a work that is both highly informative and stimulating. Not only is the scope of the work and the method of presentation original, but the author has an exceptionally wide knowledge of the literature and a talent for illustration by diagram. The book is essentially practical in outlook, and one feels all the time that the scientific facts are not given primarily for their scientific interest but because they have a definite bearing on human activities in connexion with wood. In conclusion mention must be made of the excellent index and the useful list of references.

Principles of Forest Entomology. By S. A. Graham. McGraw-Hill Publishing Co., Ltd.: London, 2nd edition, 1939. 24*s*.

Review by R. C. Fisher

THE progress that has been made in the study and control of forest insects during the past twenty years in different parts of the world is evident from the marked increase in the number of contributions by forest entomologists to scientific and technical journals, by official publications issued by Government Departments, and by the appearance in recent years of a number of new text-books on the subject. To the forester, occupied with many different problems and with little opportunity of keeping in touch with the latest advances in knowledge in the various branches of science affecting the welfare of his crops, text-books of the right type are of the greatest assistance.

In this respect, American foresters are particularly fortunate in having at their disposal two recent books on forest entomology, treating of the subject from quite different angles, but each containing information hitherto not brought together within the compass of a book. The one (*Forest Insects*, by Doan, Vandyke, Chamberlain, and Birke, McGraw-Hill Publishing Co., Ltd., 1936) discusses at length the forest importance and control of the principal injurious species, whilst others of lesser economic importance are listed with a short comment on each. The result is a valuable summary in conventional text-book form.

The other, an interesting contrast, is Professor Graham's *Principles of Forest Entomology*, first published in 1929, in which the subject is approached 'through a consideration of general underlying principles supplemented by a study of certain insect species carefully selected to illustrate how these principles apply in individual instances'. The larger part of this book discusses these principles from the ecological viewpoint.

So far as the reviewer is aware, there is no other text-book which sets itself out to deal

specifically with the underlying causes of outbreaks of forest insects, upon a knowledge of which the development of reliable methods of prevention and control largely depends. The appearance in 1939 of a second edition of this book is, therefore, most welcome. Whilst its interest for teachers and students of forest entomology has not been lost sight of, the author has added to, rather than detracted from the appeal of his book to the practical forester by omitting the questions which marked the chapter endings in the first edition, and which tended to label the work as a text-book primarily for examination purposes. For the rest, the plan of the new edition is identical with that of the first. New information has been added involving the rewriting of parts of the text, such as the chapter on insect abundance and the sections on termites and bark beetles: particular attention is given to forest insects which have recently become economically important in the United States. The main object of the revision has, therefore, been to bring the book up to date. Whilst this has been achieved for such species as the European spruce sawfly, *Diprion polytomum*, the Buprestid beetles, *Melonophila* spp., and the bark beetles of the genus *Dendroctonus*, the additional data given in some of the more general chapters are disappointing and there are numerous important omissions. For instance, in common with many American publications, few references to foreign literature are included, and one therefore concludes that recent work in countries outside the U.S.A. on insects or groups of insects of interest in that country has been overlooked by the author.

In this connexion, one of the most outstanding omissions is the absence of reference to the advances made during the past ten years in the knowledge of the physiology of nutrition of wood-boring insects, a summary of which is given by Mansour and Mansour-Bek (1934). Whilst a text-book on forest entomology is not the place in which to expect a discussion of physiological problems, their bearing upon ecological studies of the insects discussed calls for some comment, and at least a reference to the literature concerned. For instance, considerable progress has been made in investigations upon the relationship between insects and fungi, and indeed one of the most valuable additions to Professor Graham's book is a new chapter entitled 'Other Relations of Forest Insects', in which attention is drawn to some aspects of such relationships, as, for example, the part played by bark beetles in the spread of fungal diseases of trees and timber.

It is, therefore, all the more surprising to note, earlier in the text, when *Sirex* wood wasps are under discussion, that these insects 'are apparently not necessarily associated with any fungi'. The work of Cartwright in England, and Clarke in New Zealand, demonstrating the close connexion between the presence of the wood-destroying fungus *Stereum sanguinolentum*, and the eggs, larvae, and adults of *Sirex gigas* and *S. noctilio*, has apparently been overlooked.

Furthermore, no mention is made of the extensive work that has been carried out on the food relations of *Lyctus* Powder-post beetles, and of the connexion between the starch content of hardwoods and their degree of susceptibility to attack. Indeed, in spite of the additions that have been made during the past ten years by the work of Wilson, Parkin, and Phillips in England, Cummins and Wilson in Australia, and Kojima in Germany to the knowledge of the biology and control of these insects, the account given in this new edition of Professor Graham's book is identical with that in the first.

Other examples might be quoted to show that in parts at least, this up-to-date summary of the problems of forest entomology is incomplete. Despite these omissions, however, this new edition is an important contribution to the literature, describing the progress of forest insect investigations in the past, and indicating the lines along

which future work in the U.S.A. is likely to develop. It has been said of the first edition that it might prove elementary to the worker in pure entomology. The same remark may still be applied to the second edition, but to the forest entomologist, whose task it is to foresee and prevent outbreaks of insect damage to trees or timber, Professor Graham's simply written discussions of the major principles and problems involved are not only stimulating but of practical importance.

The new edition, which also includes a section on contemporary work and workers in forest entomology in the United States, is some 70 pages longer than its predecessor and is well illustrated by photographs and diagrams, including a few not included in the first edition.

NOTICES

Applied Silviculture in the United States. By R. H. Westveld. Chapman & Hall, Ltd., London, 1939. Price 25*s*.

THIS book is an indication of the spread of systematic forestry in the United States. In recent years a great deal has been published on silvicultural practice in the United States in journals and bulletins, and Professor Westveld selects this and brings it together in a useful form. The extent and variation of conditions in the United States indicate that a regional basis is the best approach for a study of this kind, and Professor Westveld divides the forests of the U.S.A. territory into eighteen regions which include the North-east Spruce-Hardwood Region, Southern Pine Region, Douglas Fir Region, Lodgepole Pine Region, Redwood Region, as well as South-eastern Alaska. In each, the principal relevant conditions are discussed: ownership, physiographic features, climatic features, historical considerations as regards lumbering, &c. He then deals with the principal forest types, and for each discusses the ecological and economic bases before proceeding to deal with silvicultural practice and disease and insect problems.

The method of approach is both scientific and practical, and Professor Westveld is to be congratulated on this volume. There is much of interest for foresters in this country, particularly in the discussion of forest types containing species that we use, such as Douglas fir, Sitka spruce, Lodgepole pine, &c. The locality data given together with the silvicultural observations on natural regeneration, and in some cases artificial regeneration, are of interest and value. For example, it is of interest that in both Douglas fir stands in Oregon and Sitka spruce in Alaska advance growth of these species is usually absent in mature stands, but that of Western hemlock and other species may be present. It is stated that Sitka spruce alone will not maintain a stand of sufficient density after middle age; hemlock alone maintains a stand of too high density, resulting in stagnation of growth and the development of a thick layer of raw humus. This effect of pure stands of tolerant species under climatic conditions such as South-eastern Alaska has a bearing on silviculture in the more northern parts of this country, and the data presented should enable us to avoid mistakes in the use of Western American conifers. Many of the observations also illustrate silvicultural points of general application.

Economics of Private Forestry. By Ralph W. Marquis. McGraw-Hill Publishing Co., Ltd., London, 1939. Price 18*s*.

THE improvement of private forestry is as urgent a problem in the United States as it is in this country. The author is an economist and not a forester, which gives the book added interest to foresters because he presents a point of view not wholly their own. He states the problem as it is in the United States, and traces its historical background. Following the termination of the pioneering stage, and the decline in birth-rate and immigration, there has been a progressive decline in *per capita* consumption of timber. Virgin timber on the Pacific coast bought when a continually expanding demand was anticipated is being forced on the market by the weight of interest charges and taxation. This depresses the price of timber and affects the profitableness of

operations in the South where second-growth timber is being cut, and discourages the private owner from developing forestry on a sustained yield basis. The basic problem is how best to deal with the transition stage between treating the forest as a mine and the organization of sustained yield. As the situation is complex, the author suggests no single panacea. While he agrees that public ownership of all forest land would solve the problem if it was carried out wisely and efficiently, he considers this unlikely. Some of the measures recommended are tax reform, low-cost credit, and fire protection. He stresses that private forest lands require good markets, and a profitable export market would relieve part of the financial pressure that is forcing liquidation.

Nineteenth Annual Report of the Forestry Commissioners for the year ending September 30th 1938. H.M. Stationery Office, 1939. Price 1*s*.

THE Report opens with a tribute to the work done by the late Sir Francis Dyke Acland. Substantial progress has been made during the year under review, 24,089 acres were planted compared with 20,107 acres in the previous year, 77 forest workers' holdings formed compared with 31, and 4,949 acres thinned compared with 4,186 acres. Acquisitions of land and the raising of nursery stock also expanded.

Some attention is given in the Report to the utilization of home-grown timber, and to private forestry. There are, however, no important pronouncements on these subjects. The progress made with the census of woodlands is discussed.

The new departure in forestry training at Oxford is recorded. It is stated that the Commissioners do not propose to follow the Colonial Office in its new method of recruitment, but to continue recruiting forest officers from candidates who have taken a degree course at a recognized forestry school.

A committee has been set up to give effect to the proposal that areas on the Commission's forests should be reserved and left unplanted for ecological studies.

Under research and experiment it is noted that experimental plots on the poorer types of peat in the north and west of Scotland are giving encouraging results. On upland heaths, e.g. in Morayshire, mixed plots of *Pinus contorta* and Sitka spruce are showing better growth than plots of pure Sitka spruce. On heath areas at Wareham, Dorset, however, *P. contorta* has developed a curious disease which is similar to that known as 'fused needle' on pines in Australia. The cause is at present unknown.

The Growth, Structure, and Properties of Wood. Forest Products Research Special Report No. 5. H.M. Stationery Office, 1939. Price 9*d*.

THIS interesting report, prepared by Mr. S. H. Clarke, summarizes the work which has been done at the Laboratory during the past ten years on the reasons for the physical properties of different species of timber, and their variation. Some of this work has been published in this Journal.

It is noted that the physico-chemical nature of the cell-walls is of greater importance than anatomical structure in determining certain types of strength and other properties. For example, the degree of lignification of the secondary walls of the fibres enables the compressive strength of specimens to be estimated with greater accuracy than is possible where only specific gravity and gross anatomical structure are taken into account. The literature on the influence of site factors on lignification is discussed. The use of specific gravity, ring width and proportion of summerwood in ring-porous woods as indications of strength are considered. The two latter add little information

to that given by the first-named, except as visual indications. The Report is suitably illustrated, and there is a bibliography.

Strength Tests of Structural Timber, Part 4. *The Development of a Minimum Structural Grade for Redwood.* Forest Products Research Records, No. 28. H.M. Stationery Office, 1939. Price 6*d.*

THE Record discusses the means of recognizing whether material is suitable for buildings where strength is important. The idea is the classification of timber according to defects in fluence strength rather than appearance.

The Manufacture of Charcoal in Portable Kilns. Forest Products Research Records, No. 29. H.M. Stationery Office, 1939. Price 6*d.*

THIS Record brings out what are the essential conditions which must be observed in the production of charcoal and deals in some detail with the design of portable kilns. It will be particularly useful during the present war emergency.

Technical Properties of Latvian Coniferous Timber (*Pinus silvestris* L., *Picea excelsa* L., *Larix Europea* DC.) *with relation to conditions of Growth.* By A. KALNIŅŠ and R. LIEPIŅŠ. Reports of the Latvian Forest Research Station, x, 1938.

THIS publication in English contains interesting data on the properties of Latvian coniferous timber. Some points of interest are as follows. Attention is directed to variations in strength factors, e.g. compression parallel to the grain and, as large numbers of specimens were tested, the data is of interest. Taking the Kraft system of classification of trees, studies were made on resistance to compression, &c., in the different classes. Strength increased from Class I, predominant trees to Class IV suppressed. Studies on the influence of age, position in the tree, &c. are included.

An interesting method of increasing the durability of timber, e.g. Scots pine for telegraph poles is described. One or more summers before felling, strips of bark 3 to 25 centimetres wide are cut every six or seven days during the summer, either horizontally or vertically. This greatly increases the resin content of the sapwood, and it is claimed greatly increases durability.

Forest Trees and Timbers of the British Empire, IV. *Fifteen Uganda Timbers.* By W. J. EGGELING and C. M. HARRIS. Oxford, at the Clarendon Press, 1939. Price 7*s.* 6*d.*

THIS volume does for certain Uganda forest trees what has already been so well done for important species in East, West, and South Africa. For each species described, a general description of the tree, botanical description, distribution, ecological notes, natural regeneration, and timber qualities are given. As before, the illustrations are a noteworthy feature.

Kiemplantenziekten van Coniferen. By J. G. Ten Houten. Utrecht and Amsterdam.

THIS publication in Dutch, with an English summary, deals with damping-off of coniferous seedlings. It is stated that this is an important source of loss in some nurseries in Holland. Isolation tests from diseased seedings produced many different fungi. Inoculation tests were then made using Scots pine and Austrian pine as hosts. The first experiments were made in pure culture in glass tubes, partly in nutrient solution and partly on autoclaved soil. The most destructive parasites were: *Rhizoctonia solani*, *Pythium de Baryanum*, *P. intermedium*, *Fusarium oxysporum*, *F. solani*, *F. scirpi*, *F. orthoceras*, *Cylindrocarpon didymum*, *C. radicicola*, *Coniothyrium pityophilum*, *Naemosphaere rostellata*, *Botrytis cinerea*, *Botryodiplodia theobromae*.

It is of interest to note that the virulence of certain of the fungi varied with the medium on which they were grown before bringing them into the soil. Investigations were made on the influence of the nature of the soil on the rate of damage by damping-off fungi. Damage by *Rhizoctonia* was least on pine forest soil which was most acid. The author concludes that this parasite is not an important cause of damage on soils of pH 4·5 or less. In studies on the influence of season of sowing on damping-off, March–April sowings were best.

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